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PROCEEDINGS

PAPER IN THIS NUMBER.

"The Operation and Maintenance of the Utilities at Army Camps and Cantonments." Geo. A. Johnson.

CURRENT DISCUSSION.

Paper.	Authors.	Published.	Discussion Closes.
"The Disposal of Sewage by Treatment with Acid."	Edgar S. Dorr and Robert Spurr Weston.	April.	June 10.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, April 16, 1919. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 7.50 o'clock by the President, Leonard Metcalf.

There were present 105 members and visitors.

On motion of Mr. Hodgdon the reading of the record of the annual meeting in March was dispensed with, and it was approved as printed in the April JOURNAL.

The Secretary reported for the Board of Government that it had elected to membership in the grades named the following candidates: Members: Elliot Howes Gage, Ralph Temple Jackson, Carl Bicknell Reed and Gorham Horatio Whitney. Junior: John Joseph Falkenberg.

He also reported that, under authority of a vote of the Society at the annual meeting, the Board had appointed the following committees for the ensuing year:

On the Library: S. Everett Tinkham, chairman; Gordon M. Fair, Howard B. Luther, Frank A. Marston, Barzillai A. Rich.

On Publication: Sturgis H. Thorndike, chairman; Sanford E. Thompson, Arthur S. Tuttle.

On Run-Off Available for Water-Power Purposes: Arthur T. Safford, chairman; Harold S. Boardman, Arthur C. Eaton, X. Henry Goodnough, Richard A. Hale, Chas. H. Pierce, Walter H. Sawyer, Charles W. Sherman, W. Frank Uhl, Frank E. Winsor, Dana M. Wood.

On Membership: Harry F. Sawtelle, chairman; Wm. W. Bigelow, Leroy G. Brackett, Arthur C. King, Thomas F. McSweeney, Chas. R. Main, Thornton R. Stenberg, Philip W. Taylor.

On Social Activities: Charles R. Berry, chairman; Armand W. Benoit, Anthony S. Coombs, Harrison P. Eddy, Jr., Ralph W. Horne, Angus B. MacMillan, David Sutton, Philip B. Walker.

On Papers and Program: Leonard Metcalf, chairman; John B. Babcock 3d, John E. Carty, Luzerne S. Cowles, John R. Nichols, Reeves J. Newsom, George E. Russell, Sanford E. Thompson, S. Everett Tinkham, Dana M. Wood.

The following vote passed at the annual meeting was passed a second time as required by the By-Laws, by a unanimous vote:

Voted: That the dues of all members in the military or naval service of the United States or its allies be abated, on request, for the proportional part of the year 1919-20 that they remain in the service; and that a sum not exceeding five hundred dollars be appropriated from the income of the Permanent Fund to reimburse the Current Fund of the Society.

The President called attention to the announcement in the notice of the meeting with relation to the appointment by the Board of Government of a committee to investigate and report

to the Society upon the compensation of engineers, and he urged the members to aid the Board in the selection of a committee which will command the confidence of the members of the Society, by suggesting the names of men most desirable for membership upon this committee.

The President spoke of the proposed meeting in Chicago to be held April 23 to 25 in relation to the creation by Congress of a Department of Public Works, which meeting had been called by the Engineering Council, and to which this Society had been invited to send a delegate. The Board of Government had accepted the invitation and had appointed Past President Frederic H. Fay to represent the Society at the meeting, and the President asked Mr. Fay to say a word about the proposed meeting. Mr. Fay said in part:

"The idea of a National Department of Public Works is an old one. More than thirty years ago this Society was represented at a conference of engineering societies at Cleveland on this matter. Mr. Clemens Herschel chose it for the topic of his presidential address before this Society in 1891, and a quarter century later as President of the American Society of Civil Engineers he again referred to it in his presidential address before that Society. Repeatedly the subject has come up in many ways and at many places. While so far unsuccessful, the fact that the idea will not down is an indication of its merit. At each recurrent period, it has gathered more strength, until now, in the light of our war experiences, there is believed to be a widespread sentiment in favor of the project.

"At the present time, there are twenty-one bureaus of the Government under five different cabinet officers, having to do with engineering, architectural and construction work of a civil character. This is aside from military engineering work such as fortifications built by the Army, and the work of the Bureau of Yards and Docks of the Navy Department. The division of this work among twenty-one bureaus and several departments with the resulting lack of coördination certainly does not promote economy and efficiency.

"During the past two years, the necessity for coördination of effort and the avoidance of overlapping and duplication has been brought forcibly to our attention by the experience of the war. At first, various bureaus of the War Department undertook, each for itself, to carry out various kinds of construction work throughout the country, and for a time there was a great

deal of confusion and overlapping, and conditions became almost chaotic. Contractors working under the different bureaus were bidding against one another for labor and for materials, until it was recognized that, if we were to successfully prosecute the war, something would have to be done to coördinate all of the construction activities of the War Department. Meantime, the Cantonment Division of that department, an organization composed almost exclusively of officers enrolled from civil life, set up for the purpose of building the camps and cantonments to house the great army which was being drafted, had carried out its work with such promptness and efficiency that, in the fall of 1917, orders were issued by the Secretary of War directing that thereafter the Cantonment Division should be known as the Construction Division of the Army and should have charge of all construction work for all bureaus of the War Department in this country. Thereafter the War Department construction work proceeded in an orderly and coördinated manner, materials were purchased through a central agency and allocated to points where they were most needed, and to date the Construction Division has carried through most successfully work aggregating in value more than a billion dollars.

"This example of unification of construction work as a war measure has brought strongly to the front, at the present time, a country-wide demand for similar unification as a permanent peace measure. It is now proposed to unite the civilian, engineering, architectural and construction work of the Government under a central control so far as possible, either by establishing a new cabinet officer, that of Secretary of Public Works, or by uniting the various bureaus having to do with work of this nature under an existing cabinet officer, perhaps the Secretary of the Interior.

"Engineering Council, which as you know is a body representing the four national societies of civil, mechanical, mining and electrical engineers, has strongly endorsed the idea of a National Department of Public Works and has taken the first step in the movement toward its accomplishment by calling a conference in Chicago, April 23-25, of representatives of about 180 engineering, architectural and contracting organizations. At this conference, which is nation-wide, the question of a National Department of Public Works will be discussed in all its phases, and if the idea is received with favor by the delegates, as no doubt it will be, definite steps will be taken to introduce into, and secure the passage by, Congress of a measure for this purpose.

"A questionnaire has just been sent out by Engineering Council, asking for expressions of opinion of the organizations

invited to the conference, upon various questions relating to a National Department of Public Works and upon the various bureaus of the Government which should be included therein. It would seem that, at this time, this Society does not have at hand sufficient information to pass intelligently upon this questionnaire in detail, but that we are sufficiently informed to express our opinion upon the general question of the establishment of a National Department of Public Works. Accordingly your speaker offers the following motion:

"Voted: That the Boston Society of Civil Engineers approves the general principle that the engineering activities of the Federal Government be coördinated and concentrated, so far as practicable, under a single responsible head; and further approves the action of the Engineering Council, by its chairman, in calling together representatives of the various engineering organizations of the country, for the discussion and study of the subject and the formulation of a definite plan of action in the premises."

The motion was adopted by a unanimous vote.

The President then called on the first speaker of the evening, Lieut.-Col. Benjamin W. Guppy. With the aid of maps thrown on the screen, Colonel Guppy spoke most interestingly, taking for his subject, "A Year with the British Expeditionary Force."

The second speaker was Major Lewis E. Moore who took for his subject "Military Bridges." Major Moore described, with the help of lantern slides, the various phases of military bridge work with which he was engaged while in France, including the design of standards, field reconnaissance, construction of new bridges in the field and maintaining and strengthening of existing bridges.

Adjourned.

S. E. TINKHAM, *Secretary.*

ROLL OF HONOR.*

ADDITIONS.

- EMERSON, GEORGE D. Captain, Q. M. C., Const'n Div., U. S. A.; Asst
Constructing Quartermaster, Boston Army Supply Base.
† MAILEY, J. BRUCE. Signal Corps, Aviation Section, U.S.A.

REVISION.

- SPEAR, WALTER E. Major, Q. M. C., U.S.A., Constructing Quartermaster,
Camp Upton, N. Y.

LIST OF MEMBERS.

ADDITIONS.

- FALKENBERG, JOHN J. Mass. Inst. of Technology, Cambridge, Mass.
GAGE, ELLIOT H. 518 Main St.; South Weymouth, Mass.
JACKSON, RALPH T. 3 River-Street Pl., Boston, Mass.
LYONS, TIMOTHY L. 294 Washington St., Boston, Mass.
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REED, CARL B. Box 112, Norwood, Mass.
WHITNEY, GORHAM H. 35 Irving St., West Medford, Mass.

CHANGES OF ADDRESS.

- BARTLETT, CHAS. H., 2632 Whitehall Bldg., 17 Battery Pl., New York, N. Y.
COWLES, M. WARREN. . . . Care State Dept. of Public Health, Springfield, Ill.
DEMING, GUY S. German Valley, N. J.
DORSEY, THOMAS F. Box B, Foxboro, Mass.
FEAR, HOLBERT W. 74 Prospect St., Gloversville, N. Y.
FIELDING, WILLIAM J. Box 592, Cristobal, Canal Zone
FOLEY, ERNEST L. 35 Bennington St., Newton, Mass.
GAUTHIER, ALMON I. B. & M. R. R., Concord, N. H.
GILES, ERNEST P. 303 Ave. E, San Antonio, Tex.
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PORTER, ARTHUR P. 28 Crescent St., Newton Lower Falls, Mass.
RICE, ARTHUR P. 45 North Ave., Melrose Highlands, Mass.
RICE, JAMES. Apt. 51, Gardens Apts., Forest Hills, Long Island, N. Y.
SAVILLE, THORNDIKE. Univ. of North Carolina, Chapel Hill, N. C.
SHEILS, HENRY C. 1079 Columbus Ave., Boston, Mass.
TOSI, JOSEPH A. 9 John St., Worcester, Mass.
WEBB, GEORGE F. Care J. B. McCrary Co., 3d Nat'l Bank Bldg., Atlanta, Ga.

* Members who are in the service and have not yet reported that fact to the Secretary are earnestly requested to do so, stating branch of service, rank and military address.

† Has received honorable discharge.

APPLICATION FOR MEMBERSHIP.

[May 15, 1919.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

SAVILLE, THORNDIKE, Chapel Hill, N. C. (Age 26, b. Malden, Mass.) Graduate of Harvard Univ., 1914, with degree of A.B., receiving M.S. in 1917; received degree of B.S., 1914, and C.E., 1915, from Dartmouth College; received degree of M.S., 1917, from Mass. Inst. of Technology: specialized in sanitary engineering, geology and public health. From 1907 to 1910, on Panama Canal, work consisting of hydrographic surveying, current-meter observations, triangulation, meteorological observations, etc.; from 1913 to 1915, instructor in surveying, Thayer School of Civil Engrg., Dartmouth College; from 1914 to 1915, assistant in physics, Dartmouth College; from 1915 to 1917, assistant in geology, and from 1916 to 1917, assistant in sanitary engineering, Harvard Univ.; lecturer on sanitation and public health, Dartmouth College, summers of 1916 and 1917; from August, 1917, to March, 1919, in U. S. Army; held rank of 1st lieutenant, Air Service; from January, 1918, to date of discharge, in charge of construction of all water works, sewerage systems and sewage-disposal plants, and subsoil drainage at Langley Field, Hampton, Va.; from March, 1919, to date, assoc. professor of sanitary engrg., Univ. of North Carolina. Elected a junior February 21, 1912, and now desires to be transferred to grade of member. Refers to A. S. Crane, E. C. Sherman, C. M. Spofford and G. C. Whipple.

EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

MEN AVAILABLE.

454. Age 22. Educated in public schools. Experience covers two years as computer and assistant land accountant on railroad valuation and five months as rodman on municipal work. Prefers out-of-door work. Salary desired, \$18 per week.

455. Age 50. Educated in high and private schools. Experience has been chiefly on municipal work and building construction.

456. Graduate of Lowell high and textile schools. Has had about four years' experience as transitman, during which time has also made computations and done some drafting. Salary desired, \$22 per week.

457. Graduate of Rensselaer Polytechnic Inst., 1916. Experience has been on heavy foundation work for steel mills and survey and power-plant work.

458. Age 28. Graduate of Mass. Inst. of Technology, 1913, civil engineering course; member, B. S. C. E. Experience includes three years with Mass. Highway Commission on construction, repair and maintenance of highways, six months on building construction with prominent Boston firm, and two years as officer with 101st Engineers, 26th Div., U. S. A., having returned with rank of captain; recently discharged from service. Desires business position that calls for engineering education and experience. Salary desired, \$1 800 per year.

POSITIONS AVAILABLE.

Wanted: Engineer to take charge; also job superintendent. Large reinforced concrete buildings. One job in Boston, one out of town. Must be first class. Benjamin Fox, Inc., 15 Exchange St., Boston, Mass.

LIBRARY NOTES.

BOOK REVIEW.

CONCRETE ENGINEERS' HANDBOOK: Data for Design and Construction of Plain and Reinforced Concrete Structures, by George A. Hool, S.B., Professor of Structural Engineering, University of Wisconsin, and Nathan C. Johnson, M.M.E., Consulting Concrete Engineer, New York City; assisted by S. C. Hollister, B.S., Research Engineer, Corrugated Bar Co.; with chapters by Harvey Whipple, Adelbert P. Mills, Walter S. Edge, A. G. Hillberg and Leslie H. Allen. First edition New York, McGraw-Hill Book Co., Inc. Cloth, 6 x 9 in., pp. 885, illustrated. \$5.00.

REVIEWED BY CHARLES M. SPOFFORD.*

The purpose of this handbook, as stated in the preface, is to make available in concise form the best of present-day knowledge concerning concrete and reinforced concrete, and to present complete data and details, as well as tables and diagrams, relating to the design and construction of the principal types of concrete structures.

A careful examination of the book shows that the authors' purpose has been carried out with thoroughness and clearness. The book contains a vast amount of information and data concerning the materials and methods entering into concrete construction, the properties of concrete and the generally adopted methods of computation. Nowhere else, to the writer's knowledge, has there been collected in one volume so comprehensive a compilation of useful material relating to this important branch of engineering. Moreover, the material is well arranged, the theoretical treatment of the various topics is reasonably complete, and the book contains the most recent developments in the theoretical and practical treatment of the subject.

Several sections deserve special comment because of the original matter which they contain. Among these may be mentioned Section 2 upon "General Methods of Construction"; Section 3, entitled, "Construction Plant"; Section 10, entitled, "Moments of Rigid Building Frames"; Section 11, upon "Buildings" (particularly that portion of it dealing with flat-slab construction); and Section 19, upon "Estimating."

* Of Fay, Spofford & Thorndike, Consulting Engineers, Boston.

Sections 2 and 3 are of value not only to construction engineers and contractors, but also to designers and draftsmen who may not be thoroughly familiar with the various methods of construction adopted in the field. They contain many well-chosen illustrations as well as diagrams and tables which should be of assistance in designing form work.

Section 10 contains material which, so far as the writer knows, has not before appeared in book form. In this section, the magnitude of the moments occurring in the framework of reinforced concrete buildings under vertical loads, is treated by the slope-deflection method, as outlined by S. C. Hollister, research engineer of the Corrugated Bar Company. Numerous diagrams giving the value of the moments under various conditions of loading accompany the text. This section also contains a brief treatment of the wind stresses in such frames.

The portion of Section 11 dealing with flat-slab construction, prepared by Walter S. Edge, consulting engineer of New York City, furnishes the most complete treatment of this important phase of building construction that the writer has as yet seen. The various systems in common use are clearly described, empirical methods of computing slabs are presented, and a comparison is made of the results obtained by these methods. This section also includes data upon flat-slab patents, as well as the results of many loading tests. Sample computations of typical slabs made by various methods, such as those prescribed by the Chicago and Pittsburgh building laws and by the recommendations of the American Concrete Institute, are given, and should be of great help even to the experienced designer. This section is supplemented by the appendices at the end of the book in which the rulings pertaining to flat-slab design adopted by various cities and associations are printed at length.

Section 19, on "Estimating," by L. H. Allen of the Aberthaw Construction Company, gives an interesting exposition of the methods used by contractors in estimating costs, and has much practical value.

While a large part of the book is devoted to buildings, other forms of concrete structures, such as girder and arch bridges,

dams, standpipes and tanks, chimneys, retaining walls, reservoirs and miscellaneous structures, are treated in detail, both theoretically and practically.

In conclusion, it may be said that this book forms a real addition to engineering literature, and should be included in the library of every engineer and builder engaged in concrete design and construction.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Abstracts of Current Decisions on Mines and Mining from January to May, 1918. J. W. Thompson.

America, Americanism, Americanization. Franklin K. Lane.

Asphalt, Related Bitumens and Bituminous Rock in 1917. John D. Northrop.

Coal South of Mancos, Montezuma County, Colorado. A. J. Collier.

Combustion Experiments with North Dakota Lignite. Henry Kreisinger and others.

Contributions to Economic Geology, 1917: Part I.—Metals and Nonmetals except Fuels. F. L. Ransome and others.

Decision as to Wages, Hours and Other Conditions in Atlantic Coast, Gulf and Great Lakes Shipyards by Labor Adjustment Board, October 1, 1918.

Decision as to Wages, Hours and Other Conditions in Pacific Coast Shipyards by Shipbuilding Labor Adjustment Board, October 1, 1918.

Fume and Other Losses in Condensing Quicksilver from Furnace Gases. L. H. Duschak and C. N. Schuette.

Genesis of Ores at Tonopah, Nevada. Edson S. Bastin and Francis B. Laney.

Geologic Reconnaissance for Phosphate and Coal in South-eastern Idaho and Western Wyoming. Alfred Reginald Schultze.

Geologic Reconnaissance of Inyo Range and Eastern Slope of Southern Sierra Nevada, California. Adolph Knopf.

Geology and Ore Deposits of Yerington District, Nevada. Adolph Knopf.

Gold, Silver, Copper and Lead in Alaska in 1917. G. C. Martin.

Gold, Silver, Copper, Lead and Zinc in Nevada in 1917.

• V. C. Heikes.

Health Almanac for 1919. R. C. Williams, editor.

Labor Saving at Limestone Quarries. Oliver Bowles.

List of References on Panama Canal Zone.

Oxidized Zinc Ores of Leadville, Colorado. G. F. Loughlin.

Plan for Operation of New American Merchant Marine.

Edward N. Hurley.

Preliminary Report on Mining Districts of Idaho. Thomas Varley and others.

Production of Lumber, Lath and Shingles in 1917. Franklin H. Smith and Albert H. Pierson.

Quarry Accidents in United States during Calendar Year 1917. Albert H. Fay.

Quicksilver in 1916. H. D. McCaskey.

Relation of Landslides and Glacial Deposits to Reservoir Sites in San Juan Mountains, Colorado. Wallace W. Atwood.

Secondary Metals in 1917. J. P. Dunlop.

Studies on Treatment and Disposal of Industrial Wastes.

Harry B. Hommon and Emery J. Theriault.

Sulphur Dioxide Method for Determining Copper Minerals in Partly Oxidized Ores. Charles E. Van Barneveld and Edmund S. Leaver.

Testimony of Matthew C. Brush in Hearing before Committee on Commerce, United States Senate, in Investigation of All Matters Connected with Building of Merchant Vessels under Direction of United States Shipping Board Emergency Fleet Corporation, 1919.

Tin in 1917. Adolph Knopf.

Results of Triangulation and Primary Traverse in Ohio, 1898 to 1911, inclusive. R. B. Marshall.

Water-Supply Papers 414, 422, 425 — D, E.

What the National Forests Mean to the Water User. Samuel T. Dana.

World Shipping Data: Report on European Mission. Edward N. Hurley.

City and Town Reports.

Boston, Mass. Annual Report of Public Works Department for 1917.

Danvers, Mass. Annual Report of Water Commissioners for 1918.

Detroit, Mich. Report of Water Commissioners on Investigation of Detroit Water Supply with reference to Filtration and Other Improvements including Results of Operation of Experimental Filtration Plant, 1919. R. Winthrop Pratt.

Leominster, Mass. Annual Report of Water Commissioners for 1918.

Melrose, Mass. Annual Report of Park Commissioners for 1918.

New Bedford Mass. Annual Report of Water Board for 1918.

Pittsburgh, Pa. Annual Reports of Bureau of Engineering for 1915 and 1916.

Plymouth, Mass. Annual Report of Water Commissioners for 1918.

Rochester, N. Y. Report on Problem of Street Cleaning, 1918.

Woburn, Mass. Annual Report of Department of Public Works for 1918.

Miscellaneous.

P. H. Dudley's Condensed Diagrams of Inspection of B. & A. R. R., 1897. Gift of A. P. Rice.

Highways of Europe. Arthur H. Blanchard. Gift of author.

Modern Methods in Motor Transportation: Report of Proceedings of First Semi-Annual Motor Transportation Conference, 1918. John R. Eustis, Ed. Gift of A. H. Blanchard.

Water Power Engineering. 2d ed. Daniel W. Mead.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

**THE OPERATION AND MAINTENANCE OF UTILITIES
AT ARMY CAMPS AND CANTONMENTS.**

BY GEORGE A. JOHNSON,* LIEUTENANT COLONEL, QUARTERMASTER CORPS,
U. S. A.

(Presented before the Sanitary Section March 5, 1919.)

THE construction of the establishments built in the last year and a half by the Construction Division of the army is an achievement unparalleled in the history of engineering. In speaking of it there is always a tendency to draw a parallel between Panama Canal construction and the accomplishments of the Construction Division. You will all recall that ten years were required to build the Panama Canal, at a cost of some \$375-000 000. In a year and a half the Construction Division built works totaling a cost of over \$1 000 000 000 — nearly three times the cost of the Panama Canal, — and this work was done at a time when there was a shortage of labor and materials, and a congestion of transportation facilities unparalleled in the world's history.

We are now going through a transition period, which in some ways is rather embarrassing. When the armistice was signed we were going strong. If the work had lasted six months longer, we would have accumulated the prettiest line of statistics on the cost and efficiency of utilities operation and maintenance ever recorded. Even so, we have already compiled from our

* Assistant to officer in charge of Maintenance and Repair Branch of the Construction Division, U. S. A., Washington, D. C.

records accurate figures of cost and efficiency in all the different branches of the utilities under our management. We are thus able to say and to prove by these records that the utilities in some three hundred and fifty-odd military establishments have been administered by the Division in a thoroughly effective, efficient and economical manner. That in itself should set apart the Construction Division as a somewhat unusual organization, because it is not unknown that such a record is not strikingly common of the management of governmental affairs. We know and are able to prove that we are obtaining water supplies, disposing of sewage, obtaining electric current for light and power, operating heating plants, manufacturing ice and maintaining buildings and roads at a cost equal to or better than the best managed commercial enterprises. Now, that is an accomplishment, and it has only been made possible by this wonderful force of skilled men who had made a success of similar work in civil life and who so willingly lent their services to the Government in this emergency.

This tremendous building program, entailing a cost of some \$1 200 000 000, was carried through with a profit to the contractors of less than 3 per cent. It is a wonderful thing, and strangely enough the magnitude of these works is but little understood. When you consider, for example, that the storage warehouses constructed by the Division would make a building 70 ft. wide and 100 miles long, you get a faint idea of the problem. You get another when you realize that in the original 32 camps and cantonments alone the total number of buildings is over 55 000. Now, all of these buildings, all of the roads (there are some 750 miles of roads in the camps and cantonments and some 450 miles in the port terminals, hospitals and regular army stations), the heating plants which require annually nearly a million tons of coal, the refrigeration plants providing ice for the preservation of perishable foodstuffs and for issue to troops, electric light and power plants, the water and sewer systems (there have been laid 3 500 000 ft. of wood-stave pipe on the water-works end, which is quite a tidy little piece of pipe laying), all require to be kept in good repair and the machinery operated efficiently and economically. That is our job, and the greater

portion of the burden falls upon the utilities officer at each establishment, who must be a homogeneous combination of building superintendent, superintendent of highways, heating engineer, refrigerating engineer, electrical expert, water and sewer superintendent, and fire marshal, as well as a diplomat of no mean ability. I say with confidence that we have dozens of just such men in the organization.

It is doubtless unnecessary for me to tell you much about the organization of the Construction Division. Last week I read an article in the *Engineering News-Record*, written by Mr. George W. Fuller, which describes quite clearly just what this organization is. There has been, however, a misapprehension in the minds of many people as to just what the term "Construction Division of the Army" means. The layman takes it for granted that the Construction Division is a part of the Corps of Engineers of the United States Army. Actually, nothing is further from the truth. The Corps of Engineers is a regular army organization, primarily interested in work connected with the activities of combatant troops. The Construction Division is a corps of engineers recruited from civil life to do work in the United States for the army which the Corps of Engineers has never done. Thus, the distinction between the two organizations becomes very plain. There have never been connected with the Construction Division more than three regular army officers since it was formed. Such members of the Engineer Reserve Corps as did become a part of it were originally recruited from civil life and were later attached to the Construction Division.

Although the officers of the Construction Division wear the insignia of the quartermaster-general's office, they are a part of that organization only because their commissions so read. The Division is in fact a separate corps, — just as is the Motor Transport Corps, for example, — and reports direct to the chief of staff and not through the quartermaster-general. It has its own funds, and disburses those funds without further reference than to the director of operations who is a member of the general staff.

Before getting into a detailed discussion of the functions of the Maintenance and Repair Branch in the operation of army camp utilities, I want to make one more general statement

concerning a sentence which appears in the announcement of this meeting. In this announcement reference is made to the "Manual of Operation of Water and Sewage Works" issued by our office for the guidance of the officers in the field, and which the writer of the announcement admits is the most complete and comprehensive document on the subject ever written. It may be that undue credit will thus be given Major Messer and myself for the preparation of this manual, but the fact is that Mr. Fales, a partner of Mr. Metcalf, spent about six weeks in Washington on the preparation of this manual, while Major Messer and I occupied the positions of editors in connection with the work, striking out here and adding there, and making things fit generally. Consequently, we do not want to take the credit, or the bulk of the credit, for its preparation, notwithstanding it is a very fine document, for basically it was Mr. Fales's creation.

PERSONNEL OF THE MAINTENANCE AND REPAIR BRANCH.

At the beginning of this year the personnel of the Washington office consisted of 34 commissioned officers (of which 13 were attached) and 126 civilian employees, nearly half of the last named being engaged on work for the entire Construction Division in the drafting, photostat and blue-print rooms.

Assisting Colonel Hartman in the Washington office are the various chiefs of sections, with their commissioned staffs and a force of civilian employees, among the latter being many of long and valuable experience in army work. This headquarters organization handles individually and collectively all inquiries, requests for information and requisitions forwarded by the camp utilities officers. The officers in the Washington office and at the camps are technical specialists, trained in civilian life in the operation and general management of public utilities.

In the camps the unit forces are composed of similar men, and consist of a utilities officer in charge, a commissioned staff of about a dozen men, and enlisted personnel ranging in number from 300 to 800, depending upon the size of the establishment.

On January 1, 1919, the personnel of the Maintenance and Repair Branch in the Washington office and in the field totaled 501 commissioned officers and 17 995 enlisted men.

FUNCTIONS OF THE MAINTENANCE AND REPAIR BRANCH.

The Maintenance and Repair Branch of the Construction Division is charged with the operation, maintenance and repair of utilities at military posts, camps, cantonments, hospitals and other organizations coming within the jurisdiction of the War Department in the United States and dependencies. It has administrative charge, and therefore obtains the necessary authorizations, establishes policies and fundamental standards relating to the operation and maintenance of water supply, sewerage and drainage, electrical, heating, refrigeration and fire-prevention systems, the upkeep and repair of buildings, roads and other fixed properties at such establishments. It exercises supervision over new construction of lesser magnitude, and additions and extensions to existing plants and systems. Especially is this true at posts or camps where constructing quartermasters have been withdrawn upon the reduction of construction work to a point where it can advantageously be handled by the utilities organization.

The Maintenance and Repair Branch selects officers to operate the utilities in these establishments, and directs and supervises their work. It makes allotments for maintenance and repair work from funds provided for such purposes. It consults with the Engineering Branch of the Construction Division that the data collected from actual operating experiences may be utilized to the best advantage in connection with the laying out of new work. It coöperates with all departments of the Construction Division, that conflict of ideas and policies may be reduced to a minimum, and that the general efficiency of the work of the entire Division may be maintained on the highest plane possible. It maintains such records as are necessary and of historic value concerning the projects in its charge.

On January 1, 1919, there were under the jurisdiction of the Maintenance and Repair Branch the roads, buildings, and public utilities in 46 camps and cantonments; 51 hospitals; 66 border stations; 25 supply depots and terminals and 171 regular military posts,—a total of 359 military establishments. The apportionment of funds for the use of the Maintenance and

Repair Branch for the fiscal year 1919 amounts to a total of \$62 400 000, or approximately \$1 200 000 per week.

Personnel Section.

The Personnel Section acts for the officer in charge of the Division in the appointment, promotion, elimination and assignment of officers; and the procurement, assignment and promotion of enlisted personnel. It performs certain routine functions not readily susceptible of delegation to other sections, keeps a record of commissioned and civilian personnel assigned to the Division, and coöperates with the Administrative Division as to personnel, policies and procedures.

Service Section.

This section has general supervision over all matters coming before the Branch. The mail of the Branch is first referred to this section, which handles matters not requiring expert technical investigation and decision without further reference to the specific section involved.

Construction, repair and maintenance of roads, walks, wharves, sea walls, retaining walls and drainage systems, dredging operations, care and improvement of grounds, are handled in their entirety by this section, as is also the routine of procurement of all materials required for the maintenance and repair of all buildings and systems.

Requests for authority for the purchase of supplies of various kinds are scrutinized in order to avoid errors in stating allotments to which charged, and all requisitions and matters pertaining thereto are acted upon in this branch.

Statistical Section.

This is the accounting, statistical and historical record section. Day-to-day balances are kept of the different apportionments of appropriations, and a complete record is kept of the purposes for which moneys have been expended from any allotment. Monthly reports from camps, cantonments, etc., are carefully checked and then filed in this section, as are all statistical records referring to the work of the entire Division. The histori-

cal record of the construction of each camp, cantonment, post, etc., is in the custody of this section. The preparation of maps and other drafting, blue-printing and photostat duties for the entire Construction Division are performed in this section.

Procurement Section (see Service).

The tabulation of annual repairs to buildings, systems, etc., at military posts and stations; requisitions for heavy furniture for officers' quarters; portable refrigerators; wall lockers; purchase of building materials for the Philippine Islands and Hawaiian Islands; feed boxes; coal boxes; shelving. Moving-picture outfits and rental of films are among the matters handled by correspondence in this branch, as is tent-floor construction, window screening, screening of buildings, storm doors and window shades.

Building-Repair Section.

This section exercises supervision over matters relating to location, construction, repair and extension of buildings for the shelter of officers and enlisted men, animals and stores; and for other military activities, and for administrative purposes. The construction of fences, the installation and repair of buildings, of elevators, laundry and post bakery buildings. In general, all means taken by the Government to house men and animals, and store supplies are handled by this section.

Fire-Protection Section.

This section exercises supervision over building plans with reference to fire prevention, formulates fire rules and regulations, and approves and directs the purchase and repair of fire-alarm systems, and fire-fighting apparatus and appliances.

Light, Heat, Power and Refrigeration Section.

Supervision of the operation and maintenance of the entire electrical service is handled in this section. The work includes analysis and approval of electrical contracts when energy is purchased, construction, operation, maintenance and repair

of power plants, including heating, refrigeration, pumping and electric-lighting systems, lighting fixtures and purchase of light and heat; incandescent lamps; saw mills and saw-mill equipment; supply parts; construction and repair of central and individual heating plants; inspection of boilers.

Water and Sewer Section.

This section supervises the operation, maintenance and repair of water-distributing systems, water-purification systems, pumping stations, sewerage systems, sewage treatment and disposal plants, incinerators and odorless excavators; and directs the installation and maintenance of plumbing in all buildings throughout the camps. It is responsible for the satisfactory operation of municipal water works from which military establishments are supplied, with particular reference to the adequacy and purity of the water furnished. It also handles the purchase of water by passing upon and approving all water contracts.

Utilities Officers' Reports.

The Washington office, in its endeavor to supervise intelligently the utilities in camps scattered all over the United States, requires to be kept advised as to what is going on and what are the actual needs in the camps. The utilities officer depends on this office for prompt assistance in authorizing funds for repairs and extensions, and also for advice on matters of policy and many other things.

There are two methods of acquiring information, namely, by reports of inspectors sent out to investigate, and by study of the reports of the utilities officer. It is very clearly realized that the utilities officer is kept busily engaged if he is efficiently performing the duties connected with the administration of his office, and for that reason the Washington office endeavors not to require him to do any more routine report work than is absolutely necessary. The report forms which he is required to fill out and submit at monthly intervals have been made as simple and as few in number as possible; but even so they are quite voluminous.

The monthly report from each camp contains concise statements relative to the activities of each section of the camp utilities. Until July, 1918, the arrangement and form of report was left almost entirely to the discretion of the several utilities officers. Commonly, however, a summary is given at the beginning, outlining matters of particular importance, recommendations as to needs, and what not, this being followed by detailed statements covering each of the utilities. Those utilities officers with municipal experience doubtless had the idea at first that reports were only necessary evils in connection with the job, and consequently to be suffered patiently. Actually, though, they serve a very useful purpose,—that of conveying essential information in a decisive fashion.

One of the greatest deficiencies in the early reports received from utilities officers, and in their requests for funds and authorizations, was the lack of complete explanation of the specific requirements. This caused delay in definite, final action which could easily have been avoided. Frequent circular letters of instructions as to the proper procedure for them to follow gradually smoothed out these difficulties. Still further to convey helpful instruction in this regard to the utilities forces in the field, whenever a letter or report is received from any camp which contains helpful hints, descriptions of the unique and resourceful manner in which a utilities officer overcame some difficulty or performed some unusual service, those parts of his communication are mimeographed with comments thereon by the officer in charge of the Division, and copies forwarded to the utilities officer at each camp for his information.

The reports from utilities officers do not meet the quite common fate of being filed away in the archives without examination. On the contrary they are carefully studied; first, with the object of finding out what has occurred during the month previous; and, second, to analyze the accumulated data from the viewpoint of efficient and economical operation. The reports on being received at the Washington office are scrutinized carefully by the various section chiefs, who attach memoranda to the report before passing it on to the officer in charge of the Division, where it is again studied, questions of policy and condi-

tions requiring correction are noted, and a communication with instructions, prepared with the aid of the various memoranda attached by the section chiefs, forwarded to the utilities officer. Thus the officer in the field has reason to feel that his reports serve a useful purpose; that the time spent in their preparation is well spent; and that prompt coöperation and assistance on the part of the Washington office depends quite materially on the character and completeness of the information furnished it with respect to his needs.

ROAD REPAIR.

There is no question that good roads and tidy-looking buildings go a long way toward creating a favorable impression in army camps. This branch makes a special effort in that direction, although handicapped by the lack of painting on the buildings and by the extremely heavy use to which the roads are put and the difficulty in getting competent labor to keep them up. This is important for other than psychological reasons. It is to be recalled that every man in the camp either walks or rides over the various avenues of travel several times daily, and uneven footing or rough riding not only produces discomfort but reduces efficiency, and very substantially increases the wear and tear on the rolling stock in the camp, and in consequence decreases its usefulness and adds materially to the cost of its upkeep. The utilities officers in the field have been urged to keep these thoughts constantly in the foreground, and authorizations of money and materials are always promptly forthcoming whenever requisitions are prepared in a clear manner describing the work to be done, its location, and when accompanied by a decisive statement setting forth the advantages which will accrue from such work. Where the utilities organization is short of labor, a certain amount of energy, properly applied, has resulted in the detailing by the commanding officer of sufficient soldier labor to do the work.

The original specifications called for four standard types of roads, but no single type of construction was adopted in all camps and cantonments. Bituminous macadam, asphaltic concrete, brick, and cement concrete, were the four types used. The main

arteries of traffic were in general paved with brick, concrete, asphaltic concrete and bituminous macadam, the type depending on such factors as availability of materials, type of construction equipment, character of soil and speed of construction. Considering the rough usage which these roads have received, they have stood up very well; but almost constant repairs are neces-

TABLE I.

COST OF ROADS IN CAMPS AND CANTONMENTS.

(Compiled from complete data on January 1, 1919, received from the original 32 camps and cantonments.)

Type of Road.	Type of Camp.	Area of Road. Square Yards.	Length of Road. Miles.	Cost.	
				Per Square Yard.	Per Mile.
Concrete, brick and granite block.	N.A.	667 805	62.33	\$3.13	\$33 600
	N.G.	243 853	21.27	2.31	31 100
	Totals and average	911 658	83.60	\$3.02	\$33 000
Bitulithic, bituminous concrete and bituminous macadam.	N.A.	933 366	92.53	\$2.03	\$20 400
	N.G.	321 813	31.37	1.70	17 400
	Totals and average	1 255 179	123.90	\$1.94	\$19 650
Water-bound macadam,* gravel, sand, clay.	N.A.	2 072 119	206.79	\$1.40	\$13 950
	N.G.	1 753 744	167.81	1.45	15 300
	Totals and average	3 825 863	374.60	\$1.42	\$14 500
Graded earth.	N.A.	453 200	42.90	\$0.50	\$5 300
	N.G.	765 544	70.97	0.49	5 300
	Totals and average	1 218 744	113.87	\$0.49	\$5 300
Grand totals and averages		7 211 444	695.97	\$1.56	\$16 200
Ditto, graded earth roads out.		6 009 100	582.10	\$1.77	\$18 500

* Including bituminous surfaced roads.

sary, and eternal vigilance on the part of the utilities officer is required lest the roads fall into such condition as to make their repair expensive and difficult.

In Table I are given the total road area and mileage in the 32 original camps and cantonments, together with the cost of construction thereof, as of December 31, 1918.

In explanation of the figures in this table it is probable that the returns for graded earth roads are incomplete as to mileage. Nevertheless the cost of some 114 miles of such roads affords a fair idea of the average cost of their construction.

Discussing generally the question of road maintenance in army camps, during the first half of the fiscal year 1919, the total allotments for road repair in these 32 original camps and cantonments approximated $5\frac{1}{2}$ per cent of the original construction cost. Doubling this figure gives about 11 per cent per annum, a figure certainly not excessive when due consideration is given to the intensive use to which these roads are put. Annual pre-war road-maintenance cost was about 6 per cent. of the construction cost when figured on a 5-year basis, and 8 per cent. on a yearly basis. For these camp roads about \$2 200 per mile is needed each year to keep them in satisfactory condition.

BUILDING-REPAIR SECTION.

One of the chief duties of the Maintenance and Repair Branch is the care and upkeep of all buildings at regular army posts, camps, cantonments, hospitals, supply depots, terminals, etc., wherever erected in the United States and dependencies.

The buildings erected during the war emergency were of necessity constructed in great haste and of materials most available. This necessitated the use of green lumber, which is one of the principal causes of the extensive repairs which have been necessary. Another cause contributing to the rapid deterioration of these structures is the fact that it was impracticable to paint them at the time they were erected, and since that time the use of paint for this purpose has been denied. Quite naturally, unpainted buildings of this character could not be expected to withstand the effect of the elements and the extreme rough usage to which they are subjected by the occupying troops.

Constant repairing therefore has been required to keep them habitable.

In peace times sufficient money was never appropriated to keep in repair the buildings at permanent posts and stations. At the outbreak of the war extensive repairs and replacements were necessarily indicated, and such work has formed a prominent part of the duties of the Division during the past year and a half.

The building section of the utilities organization in each camp performs somewhat similar duties to those of the superintendent of buildings in a city. It is to be recalled, however, that no city building inspector has the job of maintaining hundreds of wooden buildings, and actually directing all of the repairs thereon, as is the case with the building-repair section of this Division. Their responsibilities are similar but the volume and character of work they are called upon to do differ radically.

This section looks after all repairs, prepares all estimates for construction work of a minor character, keeps account of the moneys expended from the various appropriations on each building, and in some cases handles the billeting of troops. This last function, while not universal, seems properly a part of the duties of this department, as it is always acquainted with the condition of the various buildings available for occupancy and by assigning troops to those buildings best adapted for their use avoids the necessity of altering buildings to accommodate troops, as often happens where this function of billeting is not handled by the utilities and troops are assigned to quarters according to geographical location in the camp. New construction work of a major character, involving new barracks or extensive additions to old barracks, is handled by the constructing quartermaster, who prepares estimates for submission to this office with the approval of the commanding general in each case.

It is useless to cavil over the desirability of using seasoned lumber in the construction of these buildings, since there was not nearly the necessary supply of lumber available when these buildings were put up. It is unfortunate, however, that provision was not made for painting them in the first place, as beyond all question a material sum of money would thus have been saved

and the entire general appearance of the camp would have been greatly improved thereby.

Approval of all projects and the authorization for purchase of all materials required for the making of repairs must be obtained from the executive officer of this section, at Washington, before the forces in the field can execute any work. Exception to this is the case of emergency work, not exceeding a specified amount, which may be executed on the order of the commanding general of the camp or post. A complete enumeration of the various repairs required on the variety of buildings existing in the camps and posts need not be recited here. It is sufficient to state that probably the most frequent repairs required are broken window lights, broken sash, damaged roofing, broken window screens and screen doors, broken locks, toilet tanks and seats and plumbing fixtures. The upkeep, removal and storage of the window screens and screen doors are functions of this section, as are the stove repairs and replacement of broken parts thereof. Endeavor is always made to fix the blame for any unusual damage, whether it was due to improper operation or handling, and by thus fixing the blame considerable decrease in such damage is effected. Tracing the cause of glass breakage and fixing the blame therefor has also caused a decrease in such breakage.

The minor repairs and smaller operations which are accomplished by the utilities organization in the camps are an important factor, and are of great service and saving. Small shops under competent mechanics from the enlisted personnel are maintained where such work as tinsmithing, blacksmithing, carpentry, plumbing, electrical, etc., in their various branches are undertaken. The thousand and one minor jobs that come to these shops make them active centers. Recently the utilities in many camps have opened typewriter repair shops which have proven a great saving in time and money to the various camp organizations.

Other activities of the building-repair section are the painting of all the numerical and name signs for the building and road signs in camps, the repair and rebuilding of stacks, the repair of heaters and ranges, and the care and repair of all roofs. At the

present time the last named is one of the most active departments.

The demand for roof repairs has been so great that a special study was made to determine the cheapest effective method of making such repairs, taking into account the temporary character of the buildings in other than permanent army posts. The buildings constructed since the spring of 1917 were covered with two-ply roofing paper. Due to the speed with which they were constructed, and the green lumber used in most instances, the roofing material often was none too carefully applied, and in some cases was nailed to the joists rather than to the roof decking. The drying out of this decking has caused buckling of the roofing paper, and in some cases to such an extent as to crack it or pull it around flashings, causing leaks. Much damage to the roofs has been occasioned by walking on them for signal practice, for observation posts, fire drills, etc., and some damage has been occasioned by the careless removal of snow. In coöperation with the Bureau of Standards, an economical method of roof repairing with plastic cement was adopted, and by the proper use of this material better results have been obtained and the roofs kept reasonably watertight as a cost of about ten cents per square per year.

The inspection feature of the building-repair section has been of great value in the economical maintenance of the buildings in the camps and posts throughout the country. In the camps the work is divided geographically, and constant inspection affords the prompt repair of small damage at a small expense before such defects develop into more expensive repairs. In cases of great damage, or where the request is made upon Washington for authority to execute work which appears to be excessive, inspection is made by a special officer sent out for the purpose, and by such inspection cases can be cited where thousands of dollars have been saved, due to the special technical knowledge of the inspector who was able to advise those in the field of more economical means of securing the same or better results than by the method contemplated in their request. A typical instance is that of a hospital building which had been leased by the Government under contract requiring the Government to make

all repairs. The operating engineer on this building for the private owners was taken over by the Government to act in the same capacity. Although a new roof had already been put on the building, complaint was made to Washington that it was in leaky condition, and that a new roof should be put on. The inspector sent from this office found that at an expense of twenty-five dollars the roof could be put in first-class condition, thus saving the expense of the requested new roof, which would have amounted to approximately \$3 500.

Table 2 shows the total number of buildings in the several camps and cantonments and the average number of each class of buildings per camp; in the 32 original camps and cantonments, including remount stations and base hospitals, there are 51 927 buildings. In the national army and guard camps the average number of buildings per camp is 1 731 and 1 511, respectively.

The annual cost of maintenance and repair of buildings (Table 3), based on the figures for the six-month period ending December 31, 1918, and exclusive of any charge for soldier labor, amounts to the following per capita of camp population:

Roofing.....	\$0.32
Screening.....	0.08
Carpentering.....	5.94
Miscellaneous.....	1.76
Total.....	<u>\$8.10</u>

Commenting briefly on the maintenance cost of buildings in these camps and cantonments, it may be remarked that the cost of building construction was approximately \$100 per capita. The maintenance cost for the first year was 8.1 per cent., or about double the United States standard for pre-war maintenance of buildings of this type (Tiffany's estimate). In view of the increased cost of materials due to war conditions, the haste with which these buildings were put together, the character of the timber of which they were built, their lack of protective paint and the rough use they have had, the annual maintenance cost to date of some 8 per cent. is low. In fact, we have estimated that for the current year, in the light of material alterations and abnormal repairs which are necessary in the contonment, supply depot and terminal buildings, an expense equal to about

\$25 000 000 will be incurred. Nearly half of this will be required to put in condition the storage depots, where the contents require adequate protection. The storage warehouses alone cover an area of 42 500 000 square feet.

TABLE 2.

NUMBER OF BUILDINGS IN CAMPS AND CANTONMENTS.

National Guard Camps (16).

	Total Number.	Average per Camp.
Barracks.....	29	2
Mess and barracks.....	5 575	344
Latrines and showers.....	10,696	669
Guardhouses.....	20	1
Infirmaries.....	176	11
Garages.....	58	4
Administration.....	95	6
Magazines.....	79	5
Stables.....	3 198	200
Storehouses, etc.....	1 183	74
Total.....	21 109	1 316
Remount stations.....	1 037	65
Base hospitals.....	2 081	130
Grand total.....	24 227	1 511
Average size, 1 632 sq. ft.; 20 290 cu. ft.		

National Army Camps (16).

Officers' quarters.....	2 012	126
Barracks and mess.....	4 338	271
Barracks, no mess.....	2 254	141
Mess buildings.....	331	21
Guardhouses.....	874	55
Infirmaries.....	266	17
Administration.....	455	28
Lavatories.....	7 730	483
Bakeries, firehouses, garages, shops, etc.....	647	40
Storehouses, sheds, stables.....	6 604	413
Camp activities.....	306	19
Total.....	25 817	1 614
Remount depot.....	859	53
Base hospitals.....	1 024	64
Grand total.....	27 700	1 731
Average size, 2 725 sq. ft.; 40 280 cu. ft.		

TABLE 3.

NUMBER, AREA AND CUBICAL CONTENTS OF CANTONMENT BUILDINGS AND
COST OF MAINTENANCE AND REPAIR.

	No. of Buildings.	Area, Sq. Ft.	Volume, Cu. Ft.
N. G. camps (16).....	21 109	27 599 799	329 997 586
N. A. camps (16).....	25 817	64 155 154	962 327 300
Embarkation and Quartermaster- training camps (5).....	2 612	5 364 179	80 462 682
Remounts (37).....	1 956	12 166 117	145 993 407
Base hospitals (21).....	3 316	12 455 940	186 839 100
Totals.....	54 810	121 741 189	1705 620 075

*Expenditures for Maintenance of Buildings for six months, July 1 to
December 31, 1918.*

N. G. camps,	\$26 361.52	\$ 6 590.38	\$483 733.89	\$142 352.48	\$ 659 038.27
N. A. camps,	41 189.84	10 297.46	755 833.56	222 425.90	1 029 746.76
Embarkation,	47 323.00	12 735.75	865 372.62	255 843.70	1 170 575.01
Hospitals....	47 472.96	11 868.24	871 128.80	257 353.98	1 186 824.00
Totals.....	\$162 347.32	\$41 491.83	\$2 976 068.87	\$877 976.06	\$4 046 184.04

Average cost of maintenance and repair was 0.24 cent per cubic foot. The total population quartered averaged approximately 1 000 000. On this basis the cost of maintenance and repair of buildings for six months' period, ending December 31, 1918, was \$4.05 per capita, or \$8.10 per annum.

FIRE PROTECTION.

Fire protection in the large groups of highly inflammable wooden buildings comprising the army cantonments is a matter of vital importance. The inherent potential fire hazard was recognized in the design of the camps, and "fire breaks," or wide open spaces, were interspersed at suitable intervals, and the individual separation of buildings was given due consideration. This policy has been amply justified and undoubtedly has influenced the result that up to the present time there have been few instances where fire originating in one building has spread to another.

The distribution of first-aid fire-extinguishing appliances in sufficient number in all buildings is general, these consisting of water pails, hand-pump tanks, and fire extinguishers of the 2½-gal. and the 1-qt. type. Buildings of the hospital units and

warehouses generally have automatic fire-alarm systems, designed to give prompt notification of fires in such structures.

In each of the camps and cantonments, a fire truck and hose company has been organized. The strength of this company is about sixty men, composed chiefly of men who have had training as firemen in municipal fire departments. It is commanded by an officer with similar experience. This company is divided into sections, stationed in the several fire stations distributed about the camp. The fire companies are provided with standard fire engines and hose wagons of the municipal type, and with three or four small triple combination Howe-Ford pumping engines. Due to rough roads and the demands in bad weather conditions, these light engines have suffered quite badly, and their replacement with the heavier types of fire apparatus has followed in numerous instances.

Of course, it is vitally essential that the water supply for fire protection throughout the camp be satisfactorily maintained, and that the water, storage and pumping facilities be ample to supply these needs. In the original construction, provision was made to deliver on three minutes' notice twice the average water demand in order adequately to meet peak loads and fire-protection requirements. As an additional precaution in connection with the water supply, there is installed in all pumping stations duplicate equipment of power-generating and pumping machinery. Electric power is used to drive the units in regular operation, and the reserve units have gasoline-driven motors. These latter units are operated at frequent intervals each week, to keep them in order and in readiness for quick service.

Stringent fire regulations have been issued by the fire marshal at each of the camps and cantonments, and he is held directly responsible for their enforcement in every particular. Members of the Fire-Prevention Detachment of the fire-service personnel make periodic inspections of barracks, remount depots, storehouses, etc., reporting any dangerous accumulation of rubbish or other material violation of the fire regulations; and such violations are eliminated as promptly as possible. The hospitals call for safeguarding to a particular degree, since so many of their inmates are unable to protect themselves. In

addition to protection against fire, unusual precaution was adopted to prevent loss of life in the event of fire occurring.

The fire loss per capita has been kept down to a remarkably low figure, considering the character of the building construction in the camps. The total fire loss in army camps and cantonments, with average populations of about 30 000 during the year 1918, amounted to 46 cents per capita as against a fire loss of \$2.10 per capita throughout the United States. This is noteworthy, in view of the fact that the standards of the National Board of Fire Underwriters designate as low the per capita loss in municipalities when it is less than \$2.00 per annum. Thousands of fires started, but only four got beyond the building in which they originated, and in each case the cantonment fire department succeeded in saving a part of the building to which it spread.

It is indicative of the zeal and devotion to duty of the men concerned in the fire-protection and fire-prevention work that the number of fires and the resulting fire losses have been so small. There is evidence also of the unity of effort of the various utilities of camp activity to bring about this reduction of the fire loss. The upkeep of roads to facilitate quick response of fire apparatus; the proper maintenance of telephone, manual and automatic fire-alarm systems, permitting prompt notification of fires; due care in the heating and lighting hazard; and the well-directed operation of the water supply for fire protection, — all of these are contributing features worthy of mention as bearing on the safety of the camp from damage or destruction by fire.

ELECTRICAL SECTION.

In view of the great volume of construction work done in 1917 and the speed with which it was produced, it is not at all surprising that some mistakes were made in the electrical equipment or that some materials were more than liberally used. The camp utilities officers were instructed to bear this in mind and promptly correct any defects wherever possible. Minor defects of design and construction were readily corrected in conjunction with the daily operation and maintenance of electrical systems.

The entire electric service, from the approval of electrical contracts, where energy is purchased, to the ultimate use at the

lamps, motors or other energy-consuming devices, is operated and maintained by the Maintenance and Repair Branch. Such contracts are an index to valuable information leading to the elimination of waste and excessive costs. One of the first major efforts of this Section was a careful analysis of all important contracts for electrical energy. This analysis developed the fact that costs in some instances were excessive and unwarranted, and immediate steps were taken to secure more favorable rates.

A typical example was that at Camp Sheridan, where the contract price was 5 cents per kw. hr. for the first 50 000 kw. hrs., and all energy in excess of that amount during any current month was 4 cents. At the close of the fiscal year 1918 (June 30, 1918), bids were requested from the two central station companies available for rendering service after a physical examination of their respective properties had been made. It was therein definitely determined that each company was capable of supplying adequate and satisfactory service. The final result of this investigation was a revamping of the contract and rates, followed by better service and a reduction in rates to $1\frac{1}{2}$ cents per kw. hr. In this single instance a saving of from \$30 000 to \$40 000 annually was effected, depending upon the number of troops stationed at this camp.

A typical case involving slight changes and adjustment in generating equipment occurred at Fort Hancock, N. J. A request for funds in the amount of \$600 was made for the purpose of installing additional governing equipment on two engine-driven generating units. Investigation by this office developed the fact that no two of the several units could be synchronized and operated in parallel. Alterations of the wiring of the generators and exciters together with other minor changes, costing less than \$25, provided the remedy. This is but one of scores of similar cases rooted out by the Maintenance and Repair Division. The individual savings are not great, but collectively show figures of importance.

The routine duties of the utilities officer in the field consist in seeing to it that the necessary generating capacity is available at the power station, that the transmission lines are of sufficient size and number and properly protected, and that the necessary

transformers and service stations are of a sufficient capacity adequately to meet the demands and to properly distribute this energy where it is needed. The secondary distribution circuits, all interior wiring in buildings, together with supplying and maintaining in all camps the electrical power equipment of the pumping stations, the refrigeration plants, laundries, etc., fall within the duties of the utilities organization.

Complete operating records are kept so that it is possible to check the energy consumption and thus eliminate extravagance and wasteful use.

General comments of passing interest may include the statement that in the camps and cantonments the amount of electric wiring totals about 1 000 000 ft., or 190 miles, in each case. At Camp Funston there are 1 320 000 ft., or 250 miles of electric wiring, with 34 900 outlets.

The consumption of electric energy varies according to the geographical location of the camp, and to local variables such as transmission distances, pumping, etc., which are not the same in any two camps. Generally speaking, however, the average per capita consumption in all the camps is about 7.5 kw. hrs. per month, ranging from about 5.0 kw. hrs. in the summer to about 10.0 kw. hrs. in the winter.

The cost of electric current varies, of course, due largely to local conditions. At Camp Lewis, with water-power generation, it costs about \$0.009 per kw. hr., while at Camp Mills, with steam generation and under somewhat unusual conditions, it costs about \$0.075 per kw. hr. On the average, however, the cost of electric energy in the camps is 2.57 cents per kw. hr.

These figures give an annual per capita cost of \$2.475 for electric energy used in the camps for all purposes. The cost of operation, maintenance and repair of substations, power stations, transmission, distribution and service lines, lamp, replacements and interior wiring and fixtures, averages about \$5.50 per capita. The average total cost of electric service in the camps, therefore, is about \$8.00 per capita per annum.

In making up the annual estimates, a substantial charge is indicated for electric current at the storage supply depots. Lighting must be furnished for interior and for platforms and road-

TABLE 4.
ELECTRIC ENERGY CONSUMPTION.
(July to December, 1918, inclusive.)

Camp.	Average Population.	Cost of Energy per Kw. Hr.	Kw. Hr. per Capita.	Cost per Capita.
<i>National Army Camps.</i>				
Custer.....	33 326	.0154	53.4	\$0.822
Dix.....	43 561	.0283	32.1	0.909
Dodge.....	32 097	.0280	50.0	1.400
Funston.....	41 389	.0389	44.2	1.719
Gordon.....	33 547	.0186	33.0	0.350
Grant.....	36 475	.0271	59.7	1.618
Jackson.....	38 691	.0250	37.3	0.931
Lee.....	46 512	.0174	48.6	0.847
Lewis.....	33 223	.0091	72.3	0.656
Meade.....	42 352	.0325	54.5	1.771
Pike.....	42 700	.0157	49.5	0.777
Sherman.....	30 326	.0531	71.7	3.773
Taylor.....	41 415	.0250	35.4	0.886
Travis.....	31 675	.0314	30.6	0.961
Upton.....	31 920	.0307	62.4	1.915
Total.....	559 199			
Average.....		.0259	48.4	\$1.255
<i>National Guard Camps.</i>				
Beauregard.....	12 215	.0200	53.8	\$1.075
Bowie.....	8 045	.0315	38.6	1.111
Fremont.....	17 021	.0200	21.9	0.438
Greene.....	13 758	.0150	35.1	0.524
Hancock.....	31 785	.0154	21.3	0.329
Kearney.....	16 906	.0275	38.0	1.046
Logan.....	13 243	.0234	38.0	0.887
McArthur.....	21 319	.0261	33.8	0.881
McClellan.....	25 346	.0287	30.6	0.864
Sevier.....	20 707	.0150	31.1	0.456
Shelby.....	15 511	.0300	65.9	1.975
Sheridan.....	20 374	.0150	23.5	0.353
Ft. Sill.....	16 897		40.5	
Wadsworth.....	19 095	.0162	35.6	0.577
Total.....	270 047			
Average.....		.0220	31.9	\$0.692
<i>Other Army Camps.</i>				
Humphreys.....	23 395	.0316	37.5	\$1.301
Johnston.....	20 467	.0154	36.2	0.558
Merritt.....	19 969	.0305	53.4	1.616
Mills.....	18 369	.0750	7.1	0.422
Stuart.....	7 536	.0500	66.9	3.344
Total.....	89 736			
Average.....		.0322	34.6	\$1.113
Total all camps.....	918 982			
Average, all camps.....		.0257	42.2	\$1.082

ways. The maintenance charge is less than in camps. A total cost for electric current at storage depots for the year is figured at about \$4 760 000.

Table 4 shows the consumption and cost of electric current consumed in the camps and cantonments for the six months ending December, 1918.

STEAM HEATING.

The steam-heating plants, both central and isolated, together with the hot-water systems in camps and cantonments, are under the jurisdiction of the Maintenance and Repair Branch. These plants must be maintained at a high standard of efficiency, not only for the continuity of service, but for the comfort of every one, particularly patients in hospitals. In a number of the camps one large heating unit supplies the base hospital, and from 100 to 175 individual steam-heating plants, barracks, officers' quarters, mess halls, etc. All gas mains and gas service, together with the piping and plants for using gas, are maintained by this Division.

In connection with heating operations, the conservation of fuel is of great importance. Last summer the Fuel Administration advised that the country must save 50 000 000 tons of coal during the year. A scrutiny of the records of this Division shows that at 14 central heating plants a saving of almost 50 per cent. of the estimated coal requirements was effected by careful operation alone. The figures from which this result was computed were taken from actual consumption records from the middle of October, 1917, to the middle of May, this year. The estimated daily average coal required was 360 tons. The actual consumption was 179 tons, less than half the estimated requirement. These figures were taken from a Northern camp, where the coal cost was \$8.21, delivered at the boiler house, and the saving effected over the estimated requirements amounted in money to \$313 213.

The repairs to these heating plants can run into large figures unless the equipment is properly cared for and carefully watched and minor repairs made before they develop into major instances. In the 14 central plants above referred to, the manual repairs

amounted to considerably less than 20 per cent. of the total cost of equipment. Of this amount fully 90 per cent. was due to forced construction, such as erection of boilers and settings at base hospitals in rainy weather, and which, through necessity, had to be put in operation at once, causing the boiler settings to crack in some cases.

Something over 5 000 000 sq. ft. of cast-iron radiation is used for radiation in the cantonments alone. Camp Funston has 617 000 sq. ft. of radiation. Tens of thousands of room heaters and stoves are used, and all these have to be kept in good order by the Maintenance and Repair Division.

Refinements in the equipment of boiler houses, such as scale, water meters, gas analyses, thermometers, etc., have put the operation of Government boilers on an equal footing with high-grade commercial enterprises. Smoke from soft coal has been minimized through the use of graduated smoke screens in the hands of inspectors who rate boiler houses as to their output.

With all care exercised in its use the amount of coal consumed in the camps and cantonments (Table 5) reaches the large total of nearly 2 000 000 tons annually. The average cost of this coal was \$5.03 per ton, delivered at the camps, the amount used 1.99 tons per capita per year, involving an average cost of \$10.01 per capita annually.

Approximately 30 per cent. of the total coal consumed was used to heat the camps. This amounts to about 0.6 ton per capita as an average for all camps, and an average cost of \$3.02 per capita per year. During the extreme cold weather of last winter Camp Funston used 8 640 tons of coal per month for heating purposes, and to heat the 2 000-bed base hospital at Camp Dix during November, 1918, required 1 271 tons.

Fuel cost is not a particular concern of this Division, however. The operation, maintenance and repair of heating plants, heaters, etc., are a function of this Division. All this equipment has greatly deteriorated, extensive replacements of boiler settings, boilers and heaters are required, and from the data available from the records of last year it is estimated that for all this work for the current year the average cost will be \$9 per capita.

To heat the some 30 per cent. of the 595 000 000 cu. ft. of

storage space in the supply depots, where the one-story buildings are only sheeted and paper-roofed, furnishes a material item of expense. Under the construction circumstances just mentioned it is figured the cost for low, steady heat will be 1.5 cents per cubic foot, representing a total cost for heating warehouses of \$2 677 000 per annum.

REFRIGERATION.

In addition to refrigerating and ice-making equipment installed in a large number of regular army posts, there are installed, in various camps and cantonments, 31 cold-storage plants for the preservation of beef and other perishable products. Nineteen of these plants have ice-making equipment installed in conjunction with the refrigerating equipment. No ice-making equipment was installed at localities offering facilities sufficient to supply camp needs at a reasonable price. No cold-storage plants were installed at camps where such space was available at a reasonable price, and at a location sufficiently close to camp to insure satisfactory service.

The operation, maintenance and repair of all refrigerating equipment comes within the jurisdiction of the Maintenance and Repair Branch. To insure maximum production and minimum cost of operation, a complete method of recording and reporting operating data has been installed.

The temperature required in cold-storage rooms must be such as to satisfy the various subsistence officers. No report has been received of failure to maintain satisfactory temperatures, and in no instance has there been a spoilage of perishables traceable to a failure in refrigeration.

Prior to the installation of refrigeration plants it was necessary to keep perishable products in the refrigerator cars in which they were received. This frequently necessitated demurrage with a restriction of the available rolling stock. Since plants have been installed no reports have been received of cars having been held over the allowed time for unloading.

Ice for issue to detachments has been produced at all times where plants are installed. In several camps where the strength of the command has been much larger than originally planned

TABLE 5.
COAL CONSUMPTION IN CAMPS.
(Per annum.)

Camps.	Population.*	Bituminous.	Tons of Coal. Anthracite.	Total.
Beauregard.....	15 387	3 325		3 325
Bowie.....	6 573	4 632		4 632
Cody.....	21 200	13 085		13 085
Custer.....	29 200	154 277		154 277
Devens.....	35 460	23 000	65 050	118 050
Dix.....	38 795	20 270	56 000	76 270
Dodge.....	29 758	97 000		97 000
Eustis.....		27 000		27 000
Fremont.....	20 265	7 557		7 557
Funston.....	32 800	118 700		118 700
Gordon.....	35 815	30 000		30 000
Grant.....	33 500	228 000		228 000
Greene.....	24 000	31 603		31 603
Hancock.....	28 234	44 000		44 000
Humphreys.....	22 500	111 536		111 536
Jackson.....	32 701	39 090		39 090
Johnston.....	18 600	3 170		3 170
Kearney.....	19 931			
Lee.....	39 650	55 750		55 750
Lewis.....	34 150	69 700		69 700
Logan.....	19 220	3 600		3 600
McArthur.....	22 450	4 794		4 794
Meade.....	36 717	26 300		26 300
McClellan.....	27 200	18 953		18 953
Merritt.....	18 300	12 200		12 200
Mills.....		3 280		3 280
Pike.....	37 900	71 335		71 335
Sevier.....	21 000	41 940		41 940
Shelby.....	22 943	15 760		15 760
Sheridan.....	19 550	44 060		44 060
Sherman.....	33 000	97 500		97 500
Sill.....		22 748		22 748
Stuart.....				
Taylor.....	35 200	100 000		100 000
Travis.....	31 800	16 322		16 322
Upton.....	33 988	4 800	57 750	62 500
Wadsworth.....	25 100	35 090		35 090
Wheeler.....	20 793	42 140		42 140
Totals.....	1 000 000†	1 642 517	349 255	1 991 772
Total cost.....		\$7 391 327	\$2 619 413	\$10 010 740
Cost per ton.....		\$4.50	\$7.50	\$5.03
Cost per capita.....		7.39	2.62	10.01

* Average daily January–October, 1918, inclusive.

† Adding 58 219 for Eustis, Sill and Stuart.

for (in some instances nearly doubled), it was necessary to purchase ice locally during the excessive heat of last July and August.

Consumption of ice, during August, 1918, at 28 camps, is shown in Table 6, in which the camps are grouped relative to the mean summer temperature of their locality.

TABLE 6.

ICE CONSUMPTION IN CAMPS.

Mean summer temperature at camp location.....	55-60	60-65	65-70	70-75
Number of camps within limits included in average.....	2	9	13	4
Total tons of ice consumed during August, 1918.....	829.69	7 162.4	12 229.75	5 243
Average total population of camps.....	67 000	327 000	336 000	80 000
Maximum consumption, lbs. per capita per day.....	0.83	3.18	4.69	5.51
Minimum consumption, lbs. per capita per day.....	0.75	1.08	1.04	3.43
Average consumption, lbs. per capita per day.....	0.8	1.42	2.35	4.23

Difficulty was at first experienced in securing trained personnel for the operation of the refrigerating plants. By proper selection and training it has been possible to produce competent operators, who are now handling the equipments with a marked degree of economy and efficiency. The records of these plants show that they are being operated on a basis entirely comparable with the best commercial installation of their respective types.

Data on refrigeration secured by this Branch clearly show that the ice supply at various camps may fairly be stipulated according to the geographic location, as shown on map, Manual Q. M. C., Appendix 2044, as follows:

North of isotherm 60 degrees, 1 lb. per capita per day.

Between isotherms 60-65 degrees, $1\frac{1}{2}$ lbs. per capita per day.

Between isotherms 65-70 degrees, $2\frac{1}{2}$ lbs. per capita per day.

South of isotherm 70 degrees, $4\frac{1}{2}$ lbs. per capita per day.

To summarize, it appears from the complete data available from 28 camps and cantonments, ice consumption for refrigeration and issue purposes ranges from 0.2 to 6 lbs., and averages 1 lb. per man, or 0.18 ton per capita annually. At \$5 per ton this amounts to \$0.90 per man per year. To operate and maintain these refrigerating plants and systems costs about \$2 per capita annually, which figure includes all charges except labor.

For the three supply depots wherein perishables are stored,—the largest of these being the Chicago Storage Depot,—a total cost for refrigeration of \$280 800 per annum is indicated.

· WATER SUPPLY.

The water supply was one of the most important items to be considered in the selection of a camp site. When necessity arose of constructing on short notice the original 32 camps, there was no time for extensive investigations of the various sites offered to the Government with respect to their comparative advantages as to topography, transportation, drainage, etc. It was fully appreciated, however, that the water supply must be sufficient to meet all reasonable needs and that the sanitary quality must be beyond question. Engineers experienced in water-works planning were sent to investigate the proposed supply for each camp and report to the Cantonment Division before the location was finally approved.

The original program provided for 16 national army camps having all modern improvements, such as good roads, electric lights, water works and sewerage. Each camp was to be built to accommodate a given population in most cases between 35 000 and 45 000. The advisory engineers associated with the Cantonment Division in preparing general policies and typical plans decided that an allowance of 55 gals. per capita was sufficient for all reasonable uses. A maximum rate of 2.85 times the average rate of consumption was assumed for peak load and fire periods. On the basis of these figures the planning engineers could arrange for supplies from adjoining municipalities or for the Government to develop its own supply.

Soon after sites for the 16 major camps had been selected it was decided to build 16 National Guard camps. These were

intended only for temporary use. Instead of wood barracks the troops were to be quartered under canvas. Sewerage was not contemplated. The water-works systems consisted for the most part of wrought iron and steel piping, the main lines being generally 6 ins. in size. Under these conditions a low per-capita consumption (about 25 gals. per capita) was figured on, and the water works were planned accordingly. In the spring of 1918, when it was decided to change the tent camps into permanent camps, it became necessary to reinforce the water-distribution systems in order to take care of the increased consumption caused by the installation of sewerage and sanitary plumbing fixtures.

To meet the Government requirements it was necessary in a number of cases to install additional filter units, new pumping machinery and force mains in the case of purchased municipal supplies. The contract called for a certain daily quantity of water per day and a maximum rate of delivery at any hour of the day or night. This was due to a higher per-capita consumption at first and also to the enlargement of some of the camps beyond the originally authorized personnel. At the same time it must be remembered that there was a considerable increase in the city consumption due to the increase in population incident to the establishment of the camp. These two factors resulted in the municipal plants being taxed to their highest capacity and in some cases being seriously overloaded. The remedy was water conservation, of course, and an energetic campaign was inaugurated to reduce underground leakage and waste to a minimum. The gratifying results along this line are recorded elsewhere.

That the water supply has been of the best sanitary quality is evidenced by the health records. Since the establishment of the camps there has not been a single typhoid outbreak attributable to the water supply. It is true, of course, that general vaccine treatment affords protection. However, past experience has demonstrated that the failure of an inoculation to prevent typhoid is more than merely measureable. During the summer months of 1918 the total population in all the camps was approximately 1 000 000, of whom 2 000 can be assumed as being susceptible to typhoid, in spite of vaccination. Furthermore,

the combined population in the cities using the same supplies was much larger than the military population of the camps, and universal anti-typhoid inoculation was not followed therein. So far as the records show, there was no serious water-borne outbreak in these cities during the past year. The records are clear for the 15 camps which developed their own supplies. The combined average daily population of these was approximately 400 000, of whom easily 800 were susceptible to typhoid. The records show not a single case of typhoid attributable to the water. Each of the water-works plants was operated entirely by the utilities organization which was directly responsible for the service rendered and the sanitary quality of the water furnished.

Credit must be given to other organizations and agencies for checking up the sanitary quality of the water by means of bacteriological examinations. The larger cities maintain laboratories either at the water-works plant or in the office of the city health department. The U. S. Public Health Service, responsible for the general health conditions in the cantonment zones, also made laboratory examinations of the water either daily or several times each week. In the camps analyses were made more or less regularly at the base hospitals. With these three separate agencies checking up the supply, any deterioration in quality was certain to be discovered.

The Maintenance and Repair Branch is responsible for the delivery to each camp of an adequate quantity of pure water at all times. All matters of location are under the supervision of the Washington office, which keeps in touch with the local conditions by means of inspections and through the reports and communications submitted by the camp utilities officers.

At each camp there is an officer in charge of water and sewers, acting under the orders of the utilities officer. These men were selected from positions in civil life in themselves a guaranty of their ability. In detailing these officers to camps, due consideration was given to local conditions; for example, a man with the experience in filter operation was sent to a camp having a filter plant, or using a filtered supply from the municipality.

The utilities officer was instructed as to the importance of keeping in close touch with the municipal water-works plant and thereby exercise supervision over it. Local authorities have been made to understand that the Government is as much interested in the operation of the water-works plant as the municipality itself. The result has been that the utilities organization in safeguarding the supply for the camp has at the same time safeguarded the water used at all these municipalities.

The camp utilities officer is required to submit at the end of each month a report showing in detail the operation of the filtration plant. The amount of water filtered, the number of filters in use, the quantity of chemical used, the results of tests, etc., are recorded. These are carefully studied, and attention promptly called to any defects in the operating program.

It is gratifying to record that city authorities have in almost every instance given the fullest coöperation in providing facilities so that the plant could give as good service as possible under the existing conditions, and also accepting the suggestions of the utilities organization with respect to submitting records, reports and other information.

As to the cost of water, a study of the records shows that of all the camps 22 were furnished water by contract at an average rate of $8\frac{1}{2}$ cents per 1 000 gals., the prices ranging from 4 cents at Camp Doniphan, to $17\frac{1}{2}$ cents at Camp Fremont. With an average total daily population in these camps of 520 304 (January to October, 1918, inclusive), and a total consumption daily of 25.3 million gallons, the total daily cost amounted to \$2 153.52 per day, or \$1.51 per capita per year, for an average of 48.6 gals. per capita daily.

The average cost of $8\frac{1}{2}$ cents per 1 000 gals., considering the high cost of chemicals, coal, etc., and labor, appears very reasonable. It is not at all impossible that the actual cost of production was somewhat in excess of the rate charged.

The contracts were made hurriedly, when there was more or less competition on the part of municipal authorities to secure the location of the camps. Notwithstanding these conditions, requests for increase in rates after the contracts were executed were made in only two instances, namely, by the Arkansas

Water Company which supplies Camp Pike, and by the City of Greenville which supplies Camp Sevier. An investigation of the former case indicated that, under the conditions water was being furnished, a higher rate was justifiable. The matter was finally arranged to the satisfaction of the company by the Government agreeing to finance and also assume a part of the cost of needed additions in the plant owned by the company.

The rate at Camp Sevier was raised from 8 cents to 10 cents per thousand gallons, beginning January 1, 1919. It is also to be noted that the per capita yearly rate of 65 cents at Camp Sevier is the lowest of all the camps. In view of this and of the fact that the city had spent about \$150 000 for a filtration plant and other improvements to furnish the Government with water, it was decided that the request for a higher rate was just and proper, and it was accordingly granted.

The total cost per year for purchased water for the camps listed is a little over \$785 540. To this must be added the expense of pumping by the Government and maintenance of pumping station, pipe lines, storage tanks, etc. In this connection it must be understood that the purchased water was delivered into the elevated reservoir at the camps in only a few cases. Usually the supply is delivered into a low-level reservoir or at a low pressure, and has to be re-pumped. At Camps Pike, Kearney and Forrest, the Government maintains a booster station on the force main, in addition to the station in the camp. Hence there is an additional item of expense. Although detailed figures have not yet been submitted, it is believed that $2\frac{1}{2}$ cents per thousand gallons for this item is not far from correct. This would make a total cost of \$1 015 830, and a per capita yearly cost of \$1.95 for these 22 camps, with a total average population of 520 304.

In addition to this figure there is to be added the cost of repairs and replacements. In the case of much of the over-worked machinery, this charge will be abnormally high during the current year. These and similar charges for reservoirs, tanks, pipe lines and plumbing fixtures are estimated from the data on hand, at \$2.50 per capita per annum, making a total cost for water of \$4.45 per capita per annum, or 25.7 cents per 1 000 gals. This is a fair average figure for all camps.

WATER CONSERVATION.

Water consumption in national army cantonments during the first months of their occupancy by troops was, in the large majority of cases, exceeding the 55 gals. per capita allowance, on which the plans for the water supply of these camps were based.

When these facts were realized, and the water conservation problem was first considered, it was thought that the elimination of water waste would be a comparatively simple problem. The fact that the consumers of water were all subject to military discipline suggested the thought that if orders were issued restricting the use of water, the effect of these consumers would make itself evident by a reduction in the water consumption. That more energetic steps were required other than issuing printed orders was evident from the first inspection made.

On the first inspection the impression gained was that large quantities of water were being lost through defective plumbing fixtures. Ball cocks on flush tanks were leaking in approximately 50 per cent. of the latrines inspected. A large percentage of shower heads were also in leaky condition.

It was decided that constant and systematic inspection and repair was the only effective method of correcting these defects. The installation of round-head, self-closing faucets was seriously considered, but it was finally decided that the saving effected would not warrant the expenditure of scrapping and replacement of the present equipment. There is no question, however, that the additional cost of self-closing faucets and mechanical flushing devices on toilets would have been justified had these fixtures been available when the original construction plans were made. Self-closing faucets were authorized for all new camps and additions to camps which were building at the time construction activities ceased.

In the month of January, 1919, when the peak per-capita consumption was reached, Camp Grant reported the maximum average per-capita consumption for the month of 123 gals., while Camp Taylor reported the minimum average of 42 gals. The grand average for all national army cantonments for the month

of January was 72.7 gals. per capita. The high consumption for the winter months may be attributed, to some extent, to running water to prevent freezing and to central heating plants, without return systems.

Inasmuch as the water supply was in most cases designed on a 55-gal. per capita basis it was realized that some means must be taken to reduce the water consumption, or the systems as they were designed would prove inadequate to meet the heavy draught that always occurs during the summer months, leaving no reserve for fire protection, compulsory shutdowns, etc.

The continued reduction in per-capita consumption is evidence of the effects of the campaign against water waste. From January to May the reduction in per-capita consumption was 11.7 gals. The reports for the month of June show that the consumption was increasing to meet the increased demands of the summer months. The average per-capita consumption for that month was 62.7 gals. per day.

The majority of the national army cantonments have wood-stave pipe for their distribution mains, some 3 500 000 ft. in all having been laid in the national army and national guard camps. The camp systems as a whole are thus probably the largest water-distribution installations that have been made using wood-stave pipe.

Careful investigation revealed that, in addition to such underground leakage as might exist, there were large quantities of water being lost through careless use and defective plumbing fixtures. For this reason it was felt that efforts to reduce the consumption by controlling the waste in fixtures and careless use would be productive of better results in less time and with less labor than to center major efforts on elimination of the underground leakage.

Posters were printed urging the men to conserve water. A plan to prosecute a vigorous plumbing inspection and repair campaign was developed and put in operation, the results of which were at once apparent, the per-capita consumption for July dropping to 60.5 gals.

Considerable ingenuity was displayed by some utilities organizations in combating the useless waste of water. In some

camps the dangerous practice of partially closing valves on the main line to reduce pressure was being resorted to. The practice was forbidden when it was discovered that such means had been employed. What proved to be the most successful means of reducing waste was the use of some sort of device in each faucet and shower head to reduce the rate of delivery of these fixtures.

This method of local pressure reduction was followed in many camps with as many variations in applications as there were camps. One inserted a piece of $\frac{1}{8}$ -in. tubing back of the faucet, another a tin button with two thread holes; still another a glass marble; while the most popular device was a tapered lead plug with $\frac{1}{16}$ -in. to 3/32-in. orifices, the size depending on the pressure. The latter proved an inexpensive and easily installed device.

It was also suggested that the lowering of float balls in flush tanks on toilets would be productive of a large saving. This plan has also been adopted in most camps.

The continued reduction of water consumption throughout the summer months, when a peak consumption is ordinarily to be expected, proved that large quantities of water were being lost through useless waste and defective fixtures.

August showed a further reduction, with an average of 54.9 gals. per capita per day, while September results showed that the average was well within the maximum allowance with an average per-capita consumption for all cantonments of 49.5 gals. per day.

The possibility of underground leakage had not been entirely overlooked. Water surveys for the location of underground leakage were made at Camps Dix, Grant, Meade, Lee, Dodge and elsewhere. The results obtained in the above-named camps did not indicate that large quantities of water were being lost through underground leaks as was supposed. The high night rate naturally led to the belief that a large portion of this water was being lost through underground leaks.

At Camp Dix there are approximately 19 miles of water main, one third of which is cast iron with leadite joints. There is approximately 25 miles of service pipe ranging in size from 3-in. to $\frac{3}{4}$ -in., and about 15 000 water fixtures. By careful test it

was determined that fixtures, waste and legitimate use accounted for 400 000 gals. of minimum night rate of 600 000 gals. per twenty-four hours. It was also determined that the filling of the railroad water tank accounted for another 100 000 gals. This was previously attributed to underground leakage.

At Camp Grant a total of 48 840 ft. of main and 55 900 ft. of service pipe, after a careful test, showed a total underground leakage of 35 588 gals. per twenty-four hours. One third of the minimum night flow at Camp Meade has been located in three sections of camp; the remainder has been accounted for as legitimate consumption and fixture leakage.

Equipment was ordered and shipped to 25 camps where relatively high-water consumption persisted, and searching water surveys thenceforth became one of the important duties of utilities organizations in the camps.

SEWERAGE.

The construction of 384 miles of sanitary sewers for the 16 national army camps, and approximately 80 miles for the national guard camps, was an undertaking of no small magnitude. General instructions in regard to minimum gradients, maximum flows for regimental units, and methods of construction were issued for the guidance of the consulting engineers at the various camps. In this connection it should be remembered that at that time there were practically no data available concerning sewage flows from large army camps in this country, and there was the unknown factor relative to future extension of the camps. Experience has shown, however, that the sizes specified in the original instructions are entirely adequate.

During the fifteen months the sewer systems have been in operation very few defects have developed, a rather remarkable fact considering the haste and other unusual conditions under which they were installed. In most instances locations had to be selected and grade lines run long before the completion of the topographical maps and before the system as a whole had been put on paper. In construction the same degree of inspection and rigid enforcement of specifications such as obtain in municipal practice was not to be expected. The systems had to be com-

pleted as soon as the camp buildings were ready for occupancy, and engineering refinements had to be discarded.

Sewer sizes range from 6 ins. up to 24 ins., and in a few cases 30-in. outfall lines. Manholes were designed to be built as cheaply as possible, and were provided with wood covers. During the past summer most of these covers have been equipped with locks in order to prevent the throwing of garbage or refuse into them.

Every effort is made to prevent the access of surface water and the infiltration of ground water, particularly at camps having sewage-treatment plants. Utilities officers were instructed to watch for any indication of surface water during periods of rain, and to use every effort in locating any defective sections. Investigations of a number of camps showed that in the haste of construction the manhole tops had not been made high enough and that surface water was gaining access to the system. Orders were issued that all such manhole tops should be raised.

At a few camps trouble was experienced with sand, which found its way into the system through such low manholes as mentioned above, and partially filled up the first compartments of the septic tanks. In one or two instances the trouble was due to defective sections of sewer which had to be relaid.

In the few instances where clogging of sewers has been reported, grease has usually been the cause. The policy in regard to grease traps and their operation is discussed elsewhere.

In regard to peak flows which reached the sewage works, the variations depend a great deal on the shape of the camp. Large numbers of shower baths and lavatories are used at the same time. To illustrate, assuming that the buildings are arranged in a straight line, it will be seen that the flow from one building will follow the flow from the building in front and so on. In other words, the flow will be in a series of waves with no concentrated peak. Then assume an extreme case where buildings are located on the circumference of a half circle, with radial sewers all meeting at one point. Peak flows from the different buildings would reach the outlet at the same time, forming one large peak. Thus it is seen that the variations in flow depend much on the layout of the camp and arrangements of the sewer-

age system. Generally speaking, however, the peaks were more like the first illustration, otherwise it would have been necessary to provide disposal works and outfall sewers of much larger capacity than actually was the case.

SEWAGE TREATMENT.

When orders were issued to construct and have ready within a period of four months 32 army camps, the advisory engineers associated with the Cantonment Division were confronted with the problem of laying down a policy with respect to sewage treatment. Time-consuming investigations of local conditions at each place were out of the question. Also, it did not seem advisable to leave the decision as to type of plant and degree of treatment to the several engineers selected to look after the installation of the water works and sewerage. This policy would have involved duplication of work in preparing plans of tanks, filter beds and other units which would best be designed in the central office. Furthermore, the installation of plants representing many different types according to the ideas of engineers practicing in the different parts of the country would have been unwise, since the conditions with respect to character of sewage and variations in sewage flow were more or less similar for all the camps. Decision as to the degree of treatment was usually made in accordance with the recommendations of the engineers in the field, who were familiar with local conditions.

The type of tank adopted by the Government differs in design and method of operation from tanks previously used in municipal practice. The engineers responsible for the selection of this had to take into consideration several items: (a) Limited time for construction; (b) cost; and (c) unusual character of sewage, which contains a larger percentage of scum-forming material than municipal sewage.

The keynote of the camp-construction program at that time was speed. The camps had to be ready to receive troops early in September, the driest period of the year, when sewage works are needed most of all.

It was consequently decided to adopt a type of tank which for a number of years had been in successful use at Government

posts and reservations. Compared with Imhoff tanks, these could be constructed in a much shorter time and at less than half the cost. Furthermore, the tank is especially designed to operate on the "flotation" principle, and therefore peculiarly adapted for treating army-camp sewage.

At the same time it was recognized that the adoption of this type of tank involved a more difficult operating problem, as has proved to be the case. In view of the uncertainty as to the length of the war and that the majority of installations would be temporary only, decision in favor of speed and low first cost, rather than economy of operation, was undoubtedly a wise one.

The original tanks for receiving sewage from the main camps were, as a rule, designed on the basis of 10 gals. capacity per capita, based on the authorized personnel. For example, if the camp was built for 40 000 men, the capacity of the tanks was made 400 000 gals. Observation of the tanks in actual operation early indicated the advisability of providing larger capacity. In July of 1918 it was decided that the tanks at the major camps, with one or two exceptions, should be increased to 35 gals. per capita. Construction was authorized immediately and additional units were well on toward completion when orders were issued in November, 1918, to abandon all new construction work.

Experience with these tanks of limited capacity showed the necessity of operating them on the sedimentation principle, with the object of obtaining a high degree of clarification and not attempt particularly to secure digestion of the sludge. This method of operation required frequent removal of scum and sludge, especially from the first compartment, where it accumulates most rapidly. Instructions issued on August 1, 1918, provided for removing scum and sludge at weekly intervals when necessary. Supplementary instructions issued later provide that the combined thickness of scum and sludge in the first compartment shall not exceed five feet. As is to be expected, the material removed from the first compartment is undigested and consequently must be turned into trenches and covered with earth immediately on removal. The sludge accumulating in the remaining hoppers becomes partially digested before removal,

and usually can be disposed of on artificial drying beds without difficulty.

In brief, the greatest usefulness of this type of tank is realized when it is operated to secure a high degree of clarification with sludge digestion a secondary consideration. Naturally, this method involves a difficult and intensive operating program. Disposal in trenches of scum and sludge intercepted in the first compartment entails a relatively heavy labor item. It is doubtful if a municipality would undertake to maintain a plant of this type on account of the high operating cost. It is true that this item of expense can be reduced by allowing the several compartments to fill with sludge, but this results in a gradual increase of suspended matters escaping with the effluent, thereby defeating the primary object of tank treatment. At camps, soldier labor is not an item of extraordinary expense, and for the comparatively short intervals the majority of these plants will be maintained the standard tank has all the efficiency required.

The Government, in the matter of sewage treatment, has not only tried to conform with the state laws and regulations, but has even installed works where there was a question whether treatment was really necessary in the interest of public welfare. Sprinkling filters were installed at Camps Dix, Gordon, Meade and Pike, and in each case provision made for disinfecting the effluents with chlorine. At Newport News, sewage tanks and disinfecting apparatus were installed at Camps Hill and Stuart at the request of parties interested in the oyster-growing areas in the vicinity. Twelve of the 32 hospitals of the national army and guard camps have separate disposal works, and, of these, five include sprinkling filters and two sand filters.

So far there has not been a suit for damages instituted against the Government on account of nuisance along the stream receiving the effluent. In a number of instances where attention has been invited to certain conditions, prompt investigation has been made and such steps taken to improve the conditions as the circumstances in the case required.

GREASE RECOVERY.

One of the most interesting developments in connection with sewerage at army camps has been the importance of intercepting grease from kitchens. This subject, up to the time the camp sewage plants were put into operation, had been practically overlooked. Literature on sewerage practice in this country contains only a few references to this item, and engineers had given the matter very little consideration.

The typical plans at first adopted for sewerage systems at camps provided that a tile grease-trap should be installed on each kitchen line. These tile traps are 18 ins. in diameter and of the ordinary type on the market. As soon as the sewage tanks were put into operation it was discovered that grease was a factor to be specially reckoned with. The tile traps were found to be practically useless. Investigation of sewage tanks at the various camps showed that some of the trouble with scum was undoubtedly due to the large quantity of grease which reached the plant. The grease which was mixed with the scum and sludge made it difficult to settle the latter for removal through the sludge pipes. What was obviously required was a trap of a larger capacity to permit the liquid to come to rest or practically so. Traps should be large enough to take care of the peak loads directly after meals.

The flow from kitchens comes in sudden gushes. Experiments conducted at Fort Myer by the Sanitary Corps showed that the average flow per capita per day from the kitchens was 2.4 gals. A maximum rate of flow of 1.5 to 2.0 gals. per capita per hour was observed. However, those sudden gushes cover short periods varying from five to fifteen minutes. During a ten-minute interval, therefore, the flow from the kitchen serving 200 men on the basis of the above figures would be from 50 to 67 gals.

A trap is required of sufficient capacity to take care of these sudden surges, allow for some cooling of the liquid in passing through the trap, and to permit the accumulation of grease during the period of a week without any great reduction in the capacity of the trap. The tile traps were entirely too small to take care of the peak flows. At such times any grease which

accumulated in the trap was washed out through the outlet. The shape of the trap also has a great deal to do with this efficiency. For instance, the outlet must be so arranged as to prevent as far as possible accumulation of organic matter in the bottom.

Traps of the new type installed at the various camps had capacities ranging from $\frac{1}{4}$ gal. to $\frac{3}{4}$ gal. per capita, based on the number of men served in the kitchen. The records in quantities of grease recovered indicate that the capacity of $\frac{2}{3}$ gal. per capita for the latest type of trap is sufficient. Such a trap requires cleaning weekly.

Data from various sources show that the quantity of grease recovered per capita per year is about 10 to 12 lbs., and the market value of this grease at the present time is about 10 cents, or, in round numbers, \$1.00 per capita per year. The population of all the camps during the past summer was about 1 000 000 men. If all the kitchens had been provided with traps the total potential income per day on the basis of the above figures would have been \$2 750, — equivalent to \$1 000 000 per year. Thus the installation of grease traps instead of being an item of expense should be a source of profit. However, the money return in reality is a secondary consideration in comparison with the need of these traps for protecting the sewer lines and preventing grease from interfering with the proper functions of the treatment works. The additional expense incident to the cleaning out of sewers clogged up with grease, and sludge trouble caused at the disposal plant on account of such grease, cannot be calculated.

There is no doubt that the discoveries along this line during the past year will have an important influence on future engineering practice. Sewage from large institutions and many residential districts is very similar to sewage from camps. The advantage of grease traps in connection with such projects will quickly be recognized, particularly at places where there are treatment works.

The condition of the sewerage systems, due to grease accumulation therein, has already been referred to, as has this necessary spring program for cleaning sewers and building grease traps to prevent such accumulations in the future. Material augmentation of the disposal-plant capacity at camps will

also require to be carried forward. Extensive repairs and replacements of work-pumping machinery, and ill-conditioned or inadequate sewer lines are required. The Government cannot long expect to get by with the emergency program for sewage treatment, and in peace times the requirements as to degree of purification will be far more exacting.

This extraordinary work, and the operation and maintenance of sewer systems and plants, is estimated to cost \$6.50 per capita during the current year.

DISCUSSION.

RICHARD MESSER.* — The question of grease recovery has been one of the interesting developments, in connection with the operation of sewerage works at army camps, although the grease problem was not appreciated in the summer of 1917, when construction of the camps began. There are very few references on this subject in the literature on sewage treatment. However, from the experience at army camps we know now that many of the troubles in connection with institutional sewage plants and plants receiving mostly domestic sewage were due in part to grease.

The original specifications for sewerage systems at the camps provides for the ordinary tile traps on the market, 18 and 24 ins. in diameter and about 30 ins. in depth. It was soon evident that these traps were of very little value. As soon as it became apparent that grease was seriously interfering with the functioning of the sewage tanks, the subject of providing larger and more efficient traps was taken up. Since then traps of various sizes and shapes have been tried out, until a design has finally been evolved under the supervision of Major Doten which appears to be fairly satisfactory.

The question of the best size of trap for camp conditions has not been settled definitely. Opinions have varied as to the advisability of building traps having total capacities of $\frac{2}{3}$ gal. per capita (based on the number of men served in a kitchen) and larger traps of 2 and $2\frac{1}{2}$ gals. per capita. During the last six

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months data received from camps relative to the quantities of grease scum collected from traps of various sizes seem to indicate that the 2- and 3-gal. per capita traps are more efficient than those of the $\frac{2}{3}$ -gal. per capita type.

The following figures taken from reports submitted by the utilities officers at Camp Merritt and Camp Meade are given below. In each case the quantities collected were carefully recorded by special request from the Washington office, and for the particular purpose of securing reliable data on this subject.

CAMP MERRITT.

Capacity of Trap. Gals. per Capita.	Number of Cleanings.	Grease, Scum, Lbs. per Capita per Year.
0.30.....	3.....	17.9
0.50.....	7.....	7.2
0.60.....	82.....	16.1
0.70.....	22.....	7.4
0.80.....	9.....	11.8
0.90.....	3.....	11.1
1.....	12.....	27.3
2.....	2.....	77.7
3.....	16.....	100.1
Total.....	156	

CAMP MEADE.

Capacity of Trap. Gals. per Capita.	Number of Cleanings.	Grease, Scum, Lbs. per Capita per Year.
0-0.5.....	2.....	11.7
0.5-0.75.....	9.....	12.0
0.75-1.25.....	130.....	19.2
1.25-2.00.....	68.....	23.2
2-3.....	27.....	69.7
3-4.....	25.....	65.7
Total.....	261	

The figures for Camp Merritt are for the period beginning November 16 and ending January 28. The intervals between cleanings varied from seven to twenty-eight days, with an average interval of about fourteen days.

The Camp Meade figures are for the month of December,

with shorter intervals between cleanings, three to seven days, with an average of about five days.

The gradual increase in efficiency in direct proportion to the increase in the size of traps is apparent from the above figures. However, it should not be interpreted from these remarks that a conclusion has been reached. Reports are still coming in and will be tabulated. It is hoped that these investigations will stimulate the collecting of similar data at other places.

The most important factor which must be taken into consideration in the design of grease traps is the maximum or peak flows which usually occur directly after meal time. Experiments conducted at Fort Myer, under the supervision of the Sanitary Corps, showed an average flow from a kitchen of 2.4 gals. per capita per day, that for intervals varying from ten to fifteen minutes the flows were as high as 1.5 to 2 gals. per capita *per hour*. Assuming these latter maximum rates, the flow during a ten-minute interval from a kitchen serving 200 men would be 50 and 67 gals. respectively.

Grease traps should be placed in the kitchen drains as near the buildings as practicable. Sewage from toilets should not be allowed to flow through the traps.

The type of tank now being installed is square, with a pyramidal bottom. The depth from the flow line is about 3 ft. 2 ins. for traps of the ordinary sizes. An interesting feature is the small outlet ($2\frac{1}{2}$ ins.) extending from the hopper bottom up to the flow line. During periods of peak flows a self-cleaning velocity is created which tends to carry out any settleable material which would otherwise soon clog the outlet. About 9 ins. above the flow line is an emergency overflow. Should the outlet clog, the water level in the trap gradually rises, thereby creating a head which tends to free the outlet and at the same time flush out any light material which has collected in the hopper bottom. It should be mentioned again that Major Doten has developed all these features.

Precautions should be taken to exclude so far as possible coffee grounds and other heavier materials which would cause trouble by clogging. At camps, sink drains are provided with screens.

One of the troubles at camps was due to men removing the covers and throwing in garbage and other wastes. This was remedied by providing covers with locking devices or by making covers so heavy that they cannot be easily taken off.

To secure satisfactory results, grease traps should be cleaned at regular and frequent intervals. The usual practice at camps is to clean each trap once a week or at least once in two weeks.

In regard to the operation of sewage tanks, I might add just one more word to what Colonel Johnson has said. Since August of last year instructions have been given to operate tanks on the sedimentation principle and to regard sludge digestion as of secondary importance. Experience has shown that the secret of securing efficient clarification (and it is possible to get very good clarification from these tanks) is to keep the first compartment comparatively clean. In other words, our operating instructions state that the combined thickness of scum and sludge in the first compartment shall not be allowed to exceed 5 ft. When this amount of material has been collected it shall be drawn off whether digested or not. As a general rule, when a tank is working at capacity, very little digestion occurs in the first compartment and the sludge drawn off must be disposed of in trenches. With this method of operation the settleable material which passes into the second, third and fourth compartments will usually sink to the bottom in the form of sludge, and very little scum will be formed. The tests at Camp Custer, which were made under the supervision of Capt. C. B. Hoover, showed that it was possible to secure a very high degree of clarification. With clean tanks, the clarification, determined by Imhoff glasses, was usually above 95 per cent. and sometimes as high as 100 per cent. A removal of 90 per cent. or more of the settleable solids determined on the basis of 2-hr. settling periods, is a reasonable expectancy with a retention capacity in the tank of 10 gals. per capita or more.

The above instructions in regard to keeping the first compartment clean and drawing off undigested material applied when the sewage tanks were working at full capacity or at high rates. During the last few months the populations at most of the larger camps have been reduced at least 50 per cent. Addi-

tional tank units authorized last summer have been completed. Consequently, at the present time sewage tanks have capacities ranging from 50 to 70 gals. per capita, or about five times as great as last year.

Instructions have recently been issued to operate the tanks in rotation, in the same manner as is done at Washington, Pa., and has been tried out at Plainfield, Columbus and other places. Briefly, this method consists of running the entire flow of sewage through one tank battery until there is evidence of disgorging of settleable solids in the effluent. The battery is then cut out of service and the next put into operation. The scum and sludge, however, is not removed until all other batteries have been used. This allows a period of five to seven months for retaining sludge in the tank and during which time digestion may be expected. To facilitate digestion the large amount of settleable material which collects in the first compartment will be distributed to the other compartments at the time the unit is cut out of service.

The grease scum contains considerable impurities and water mixed with it. A carefully conducted test showed that 1 028 lbs. of grease scum were rendered into 720 lbs. of refined grease, or about 70 per cent. This grease, of course, can be used for various purposes and during the period of the war brought a price ranging from 10 to 20 cents per pound.

At Camp Gordon we have had some trouble in getting rid of the scum and sludge. One reason for this is the lack of available area in the vicinity of the plant for the disposal of sludge. The plant itself is located not very far from occupied buildings. The limited area on the hillside across the stream from the plant was practically used up last year for the disposal of sludge in trenches, and since then there has been considerable difficulty in finding suitable space for trenches. Some months ago an attempt was made to remove this sludge by pumping through a pipe line to an area located about one-quarter mile away from the tanks. This scheme was not very successful, and at the present time scum is being removed from the top of the tank and hauled away in wagons.

LEONARD METCALF.* — Perhaps I might say just one word in regard to the tanks to which Colonel Johnson has referred, with special reference to the basis of design adopted, so that it will be made clear to you. I say this because I hope that none of you will go away with the idea that these tanks can be used for municipal practice on any such basis of design as was planned in their original construction. The problem with which the Construction Division was confronted was this: The camps were to be designed for a maximum period of time of five years, with the possibility that they would not be used for more than two. It was thought that they would probably be used for at least two years, but perhaps not for a longer time than that. Therefore the designers were confronted with the question as to what was the economic line of division between first cost and operating cost, and it seemed more prudent, particularly in view of the difficulty of building the tanks in time for the occupation of the camps, to adopt a form which would involve a low construction cost and high operating cost.

The difficulty in the functioning of these tanks has arisen from the fact that many have conceived of them as being digestion tanks. Those who passed upon them originally did not so regard them — except Major Doten. We felt that they should be regarded essentially as sedimentation tanks, and if so operated the tanks would do the work of clarification, and that was all that was thought necessary in the majority of cases. Where it is necessary to carry the purification to a higher degree, it was thought additional capacity, or filters or other devices to accomplish this additional purification, could be added later. As soon as it was appreciated, by those who were operating the tanks, that they had to be operated on the sedimentation rather than the complete digestion basis, they functioned properly, and early difficulties, such as clogging, were surmounted. This did not eliminate the disagreeable task of handling the solids, however, and Colonel Johnson is quite right in saying that nobody appreciated the seriousness of the grease problem. I think that the Construction Division has contributed something

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of substantial value to the art of wastes disposal, in the grease trap which has finally been evolved by it, and of the operation of which Major Messer has told you.

As bearing on the effect of grease on sewage, I was very much interested in conditions developed at Camp Gordon, at Atlanta. The scum and sludge were distinctly acid. Some of this sludge had been taken out of the tanks and buried in trenches 8 or more feet in depth, and then covered with bagging and oil put on top to prevent the breeding of flies.

I asked them to open up some of the trenches. The sludge had been in them between two and three months, I think. It was in May or June that I saw them. No change had taken place in the sludge except a reduction in the moisture content, and the fly problem was a very serious one. Major Hommon told me he had found in some trenches where the grease was deposited and covered with 5 ft. of clayey material, that flies had come up through it. He said that he had heard of flies coming up through 4 or 5 ft. of sand, but never through this distance of clayey material. This made us very apprehensive. At that time, too, there was also considerable trouble with the development of flies in the scum in the tanks.

The tanks were being relieved of a part of the sludge and scum in them at that time, with a view to operating them on the sedimentation basis. An attempt had been made to operate them on the digestion basis, and had failed.

The day before we got there they had treated the tanks with a very heavy dose of oil, which had killed the larvæ, but we found that even then (twenty-four hours later), where the material was cracking open, larvæ were still at work, and oil had to be applied again.

We thought at that time that it might well prove necessary to handle this sludge and remove it within the life cycle of the fly.

ALMON L. FALES* (*by letter*). — It was a keen disappointment to me to be unable to attend the annual meeting of the Sanitary Section and hear Colonel Johnson's address on "The Operation and Maintenance of Utilities at Army Camps and

* Of Metcalf & Eddy, Consulting Engineers, 14 Beacon Street, Boston.

Cantonments," and the discussions by Major Messer and others. I have read with great interest the stenographer's transcript of the address and discussions, and am impressed more than ever with the magnitude and importance of the work which Colonel Johnson and Major Messer have been doing.

I appreciate Colonel Johnson's kind words concerning my part in the preparation of the "Manual of Operation of Water and Sewage Works," but feel that he gives me altogether too much credit. Although I did prepare some suggestions for Colonel Johnson along those lines while in Washington, there was so much left to be done when I came away that I feel entitled to little credit for the final document.

In connection with the work of the consulting engineers, Fuller and McClintock and Metcalf & Eddy, employed by the Construction Division, it was my privilege to inspect the water supply and sewage-treatment facilities at numerous army camps and to make careful investigation of the efficiency of these facilities in several of the camps. I am therefore in a position to testify that Colonel Johnson and Major Messer were confronted with many and varied problems in the water and sewer section alone. The Construction Division and the Maintenance and Repair Branch, in particular, is indeed fortunate that these problems were in such competent hands.

I have followed the work of the Water and Sewer Section with great interest. Where the water supply was found to be inadequate or unsatisfactory in quality, steps were taken to remedy the defects. Where the use of water was abnormally large, steps were taken to determine possible sources of leakage. In the case of leaking sewers or manholes on the sewer system receiving surface water, steps were taken to make the necessary repairs. In the case of the grease traps which were found to be unsatisfactory, provision was made for installing larger traps of improved design. In the case of the sewage tanks which were found to be inadequate for digestion of the sludge, provision was made for additional tanks of improved design. Many additions and improvements for water supply and sewage treatment were either completed or well under way when the armistice was signed.

Colonel Johnson and Major Messer have discussed the methods of operation of the sewage tanks and the difficulties encountered in the disposal of the sludge. It may be helpful to describe briefly the type of tank referred to, which was designed by Major L. S. Doten, of the Engineering Branch.

The tank installation for a divisional cantonment consists of two units of four compartments each. Each compartment is 23 ft. 6 ins. square in plan, and provides for a depth of 7 ft. 9 ins. from the water level to the top of the hopper bottom, and the hopper bottom is 6 ft. 6 ins. deep at the center, with the sides on a slope of 1 on 2. The bottom baffles, or sludge partitions between the compartments, are of concrete, and extend to within 12 ins. of the water level. A top baffle, or scum partition, also of concrete, is placed in front of each sludge partition, at a distance of 2 ft. 3 ins. from it. The distances between the top of the hopper bottoms and the lower end of the scum partitions are 18 ins., 12 ins., 6 ins. and 0 ins., in the first, second, third and fourth compartments, respectively. The sewage enters the two tanks through openings in adjacent corners and flows through the tanks in parallel, the effluent from each passing over the edge of a collecting trough extending entirely across the outlet end of the tank.

A cast-iron pipe is provided for the removal of sludge from each hopper. The pipe for the first compartment is 10 ins. in size and the others 8 ins. The ends of these pipes are notched to rest on $1\frac{1}{4}$ -in. horizontal bars placed 4 ins. above the hopper at the center. A short distance above the bottom these pipes turn from the vertical at an angle of 45 degrees and pass through the side wall of the tank, emptying into the sludge main which is of 8-in. and 10-in. cast-iron pipe. For the first compartment of each tank a vertical sludge pipe extension is afforded, for agitating the sludge to facilitate its removal.

The objects which can be attained by tank treatment of sewage without the use of chemicals may be enumerated as follows:

1. Removal of suspended matters which will settle to the bottom or rise to the top.
2. Digestion of the solids removed, with the production of inoffensive sludge and scum.

3. Reduction in oxygen requirement of the sewage, for bacterial oxidation of organic matter.

The first object (sedimentation and flotation) was obtained by the Doten tank until the accumulation of the undigested sludge and scum became so great that portions of it were carried away in the effluent at times of high flow. It then became necessary to remove a part of this accumulation, and great difficulty was experienced in getting it out, owing to the clogging of the sludge pipes, due in part to the obstruction offered by the supporting rods on which the sludge pipes rested. By sufficiently frequent removal of sludge and scum the third object (reduction in oxygen requirement) was also attained.

The second object (digestion of solids) was not attained by the Doten tank with a capacity of 10 gals. per capita, and tests at Camp Custer indicated that complete digestion of the solids could not be secured even with a capacity as high as 35 gals. per capita. In several cases some well-digested sludge was produced in the third and fourth compartments, but so far as I am aware, in no case was the rate of production of well-digested sludge equal to the rate of accumulation of undigested material. In some cases where digestion was active, the tank effluent was found to have a higher oxygen requirement than the crude sewage itself, thus defeating the third object of the tank treatment.

The provision for five tank units, recommended by the consulting engineers, was to enable the tanks to be operated in rotation, one at a time for sedimentation, followed by a period of rest for sludge digestion and thus to secure all three of the objects which may be attained by tank treatment. It was also recommended that provision be made for pumping the sludge and scum from any compartment of any tank to any other compartment, to facilitate digestion of the solids.

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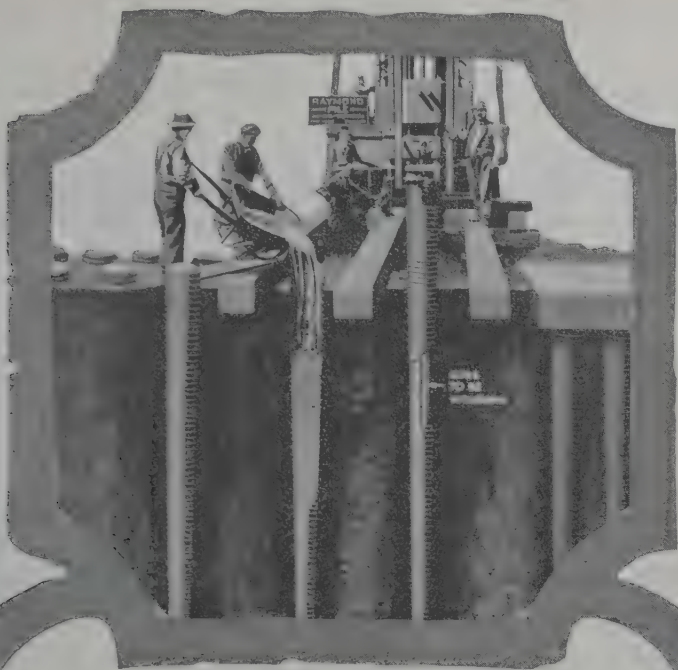
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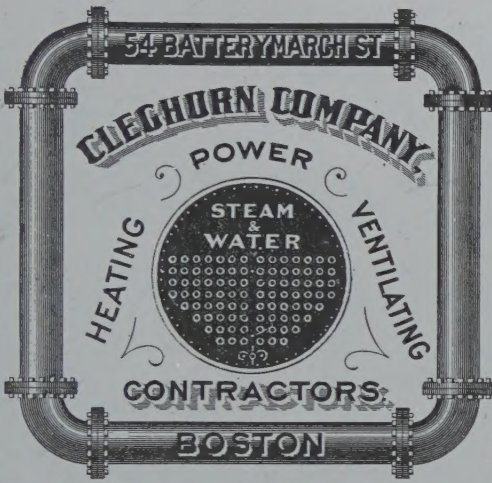
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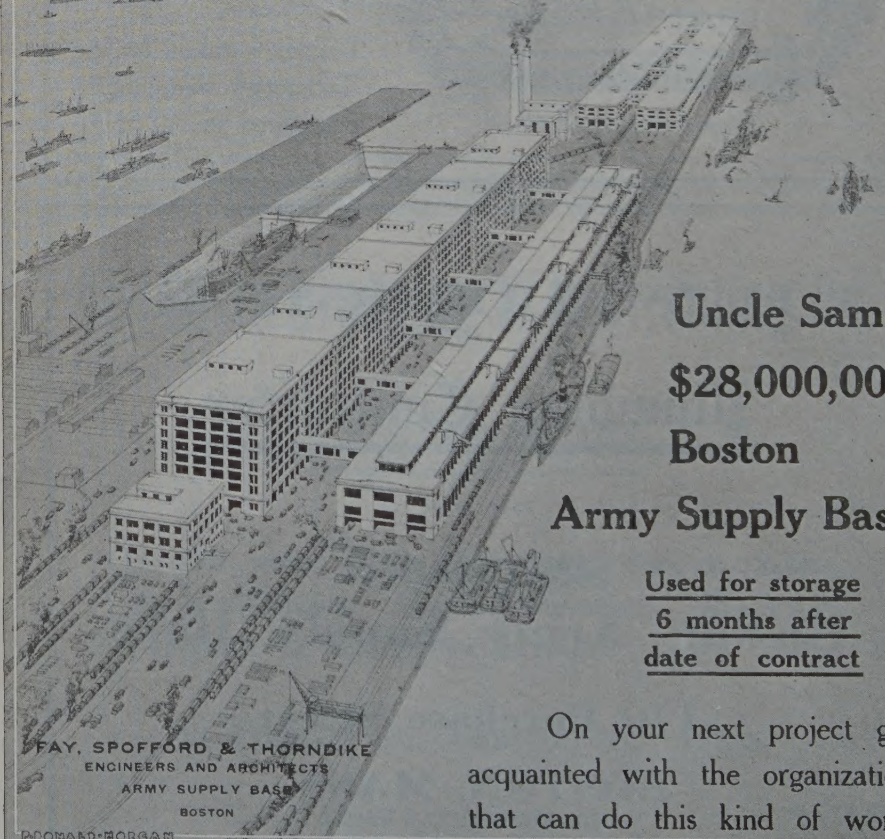
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